CAMS-MEET Users Guide

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1 Introduction

The Methane Emissions Estimation Tool (MEET) is a computer model built to simulate methane and other hydrocarbon emissions from the onshore natural gas industry over time. The model can estimate emissions from either a single facility or multiple facilities in a geographic area. Emissions are estimated using data from published research, or from custom data entered by the user. Industry segments in the model include onshore natural gas production, gathering and boosting, gas processing, and transmission and storage. The most fully developed models as of release of this user's guide are onshore production sites and midstream gathering compressor stations.

Since measurements are not available for every piece of equipment at every site, emission estimates are based on emissions measurements made on representative sub-populations. Data on emission measurements are embedded in MEET as distributions of measurements values, and therefore emissions estimates are inherently stochastic. For this reason, the MEET model uses Monte Carlo methods to determine a range of possible emissions values over the study period. This means that for a typical use case the model will run a number of iterations (i.e., Monte Carlo runs) to determine the most likely emissions scenarios.

1.1 Definitions

API Gravity	A measure of density of crude oil and condensate. API Gravity may be calculated from specific gravity (1=water) using the following formula: API Gravity=141.5/(SG-131.5)
Chemical Injection Pump	A pump used to inject chemicals into the natural gas or well fluids. They may be powered by compressed gas (air or natural gas) or electricity. Examples of chemicals injected include corrosion inhibitors and methanol.
Completion	The process of completing a well so that it can being producing. This process includes hydraulic fracturing and flowback operations.
Condensate	A light oil produced with natural gas. It may also condense in natural gas gathering pipelines due to pressure and temperature changes.
Dehydrator	A piece of equipment used to remove water from natural gas. Dehydrators may use salts (desiccant) or glycol to remove the water.
Dump Event	Transfer of oil/condensate or water from a separator vessel to storage tanks. The transfer is typically done automatically by opening a valve for a short period of time. During first production the frequency of dumps event is as high as every few seconds due to high production rates.

Flash	When Gas that is liberated from liquids such as oil/condensate or water as result of a decrease in pressure, an increase in temperature or both.
Flowback	The first fluids that are produced from the well. Typically, this is mostly sand and water as a result of hydraulic fracturing.
Gathering and Boosting Sector	Gathering pipelines and other equipment used to collect petroleum and/or natural gas from onshore production gas or oil wells and used to compress, dehydrate, sweeten, or transport the petroleum and/or natural gas to a natural gas processing facility, a natural gas transmission pipeline or to a natural gas distribution pipeline.
Hydraulic fracturing	High pressure fluid is used to create fractures in the formation rock to allow for oil and gas to flow more easily to the surface.
Plunger Lift	A method of operation of well where a mechanical plunger is used to help bring liquids to the surface. Typical order of operation includes the well is opened and the plunger is brought to the surface by pressure in the well. Once the plunger reaches the surface it remains there for a few minutes to allow all liquids to clear the well (called after flow). Then the well is shut in and the plunger is allowed to fall back to the bottom of the well.
Pneumatic controller	Equipment which uses pressurized gas to monitor and control various operations at a natural gas facility. Examples include liquid level controllers, positioners, and temperature controllers.
Processing Sector	The separation of natural gas liquids (NGLs) or non-methane gases from produced natural gas, or the separation of NGLs into one or more component mixtures. Separation includes one or more of the following: forced extraction of natural gas liquids, sulfur and carbon dioxide removal, fractionation of NGLs, or the capture of CO2 separated from natural gas streams. This segment also includes all residue gas compression equipment owned or operated by the natural gas processing plant.
Production Sector	All equipment on a single well-pad or associated with a single well-pad used in the production, extraction, recovery, lifting, separation or treating of petroleum and/or natural gas (including condensate). Production also means all equipment on or associated with a single enhanced oil recovery (EOR) well pad using CO2 or natural gas injection.
Separator	A vessel used to separate well fluid into constituents of water, gas and oil/condensate.

Shut-in	When a well is temporary closed and does not produce. This may be an automated process such as when plunger lift system is installed or manually.
Transmission and Storage Sector	Transmission includes compressors that move natural gas from production fields, natural gas processing plants, or other transmission compressors through transmission pipelines to natural gas distribution pipelines, LNG storage facilities, or into underground storage. Underground natural gas storage includes subsurface storage, including depleted gas or oil reservoirs and salt dome caverns that store natural gas that has been transferred from its original location for the primary purpose of load balancing (the process of equalizing the receipt and delivery of natural gas); it includes natural gas underground storage processes and operations (including compression, dehydration and flow measurement, and all the wellheads connected to the compression units located at the facility that inject and recover natural gas into and from the underground reservoirs.
Well Unloading	A liquid unloading may be necessary when a gas well that also produces oil or liquids accumulate in the well bore and prevents the well from producing normally. The liquids accumulation may be due to a variety of causes, including decreases in gas velocity in the well, decreases in reservoir pressure, or changing gas to liquid ratios. As liquids accumulate, well production can decline, and an operator may choose to unload the liquids from the well to restore production. Not all unloading methods lead to venting emissions, however, emissions do occur when the flow from the well is temporarily diverted to an atmospheric vent. MEET only estimates emissions from unloadings that vent to atmosphere.

1.2 Acronyms

2SLB	Two-Stroke Lean Burn
4SLB	Four-Stroke Lean Burn
4SRB	Four-Stroke Rich Burn
AGU	Acid Gas Removal Unit
API	American Petroleum Institutes
Bhp	Break Horsepower
BSFC	Break Specific Fuel Consumption
BTU	British Thermal Units

Bbl	Petroleum barrels (equal to 42 U.S. Gallons)
CAMS	Collaboratory to Advance Methane Science
CSV	Comma Separated Variable
EIA NEMS	Energy Information Administration National Energy Modeling System
FIPS	Federal Information Processing Standards
GHGRP	Greenhouse Gas Reporting Program
HHV	Higher Heating Value
Hr	Hour(s)
HTML	Hypertext Markup Language
Kg	Kilograms
Mbbl	One thousand petroleum barrels
Mscf	One thousand standard cubic feet
MMscf	One million standard cubic feet
MEET	Methane Emissions Estimation Tool
NOD	Not Operating Depressurized
NOP	Not Operating Pressurized
OP	Operating
RICE	Reciprocating Internal Combustion Engine
Scf	Standard Cubic Feet

2 Inputs

Inputs to the model are specified in the developer provided Excel intake file. A template file should be used as a starting point and modified to the user's specific needs. As described later in this manual, a few other input files for user specified leaks and compressor data can also be used but are not required.

2.1 General Input Instructions

The input sheet is a Microsoft Excel workbook. There are a number of smart features to ensure the correct information is input into the sheet including drop down lists and conditional formatting. In general, yellow ( ) cells are mandatory inputs, grey cells ( ) are optional inputs which will override defaults, and black cells ( ) are not used.

Rows in most sheets can be added by copying the last formatted row and pasting it below the last formatted row. Changes should not be made to the three sheets labeled "InternalUseOnly_..."

2.2 Sheet Instructions

The inputs for each sheet are discussed below. These instructions are for simple runs only that use many of the default values. For more advanced runs please refer the advanced instructions section of this user's guide.

Each subsection describes a sheet in the input workbook. Each input location in the sheet is described using the following format:

- General input description
- Written commentary on how to select the best option.
- A sheet that specifies:
    - The cell or column in which the input is located within the sheet
    - The format of the input (i.e. text, number, date, time, etc.) - in some cases, the format must be specific (for example the Simulation Start Date in the Global_Simulation_Parameters)
    - The units (i.e. psia, bbl, Mscf, etc.) of the input, if applicable
    - If the input has any limitations (i.e. must fall in certain range, must be from a drop down, etc.)
    - When the input required. Specifically, what other inputs must be selected in order to make the input required
    - When the input is optional. Specifically, what other inputs must be selected in order to make the input optional
    - A suggested default for that input

2.2.1 Global_Simulation_Parameters

The global simulation sheet sets the time frame, plot resolution, number of iterations and input and output locations. Each element in the sheet is described in detail below.

2.2.1.1 Simulation Start Date:

The date the model will begin calculating emissions. To use the MEET tool to correspond to emission measurement, the simulation start date should correspond to the date the measurement began.

Cell	B1
Format	MM/DD/YYY
Units	Date
Limitations	None
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.1.2 Simulation Duration

The number of days for which the MEET model will calculate emissions.

Cell	B2
Format	Number
Units	Days
Limitations	None
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.1.3 Plot Interval

The scale at which the emissions are output in the csv and html out files . The scale should be selected based on the granularity needed.

Cell	B3
Format	Number
Units	Time
Limitations	Value must be from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.1.4 Number of Monte Carlo Iterations

The number of iterations of the model to be run. The more iterations, the more accurate the probabilistic distribution will be (i.e. the likelihood of emission rates at various times during the model). However, the tradeoff is more iterations require more time for the model run.

Cell	B4
Format	Integer

Units	Runs
Limitations	none
Required if	Always
Optional if	N/A
Suggested Default	• For production sites primarily in the drilling and completion phase: 50 or less • For production sites in the producing phase: 100 or less • For compression and gathering sites: 100 or less

2.2.1.5 Output Directory

The location the user would like the output files to go relative to directory the model is being run from. Actual output directory will have time stamp for the simulation run appended to the name.

Cell	B5
Format	Relative File path
Units	N/A
Limitations	none
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.1.1 Tank Flash Saver Interval Threshold

The frequency at which a dump event information is saved for the output. This does not affect the number of dump events modeled just how they appear in the output. Dump events may occur every few minutes which generates many data points in the output. For models with a short simulation duration the tank flash saver interval threshold may be shortened to a value shorter than 60 min.

Cell	B6
Format	number
Units	Minutes (min)
Limitations	none
Required if	Always
Optional if	N/A
Suggested Default	60

2.2.2 Facility_List

This sheet specifies facility level information including data such as location, sector, emission composition and source of emission data for fugitives and pneumatics.

2.2.2.1 Facility_ID

A unique facility ID for each facility to be modeled. This can be facility name or number.

Column	A
Format	Text or number
Units	N/A
Limitations	none
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.2.2 Latitude

The latitude of each facility to be included in the model. The model is currently only designed to be used for locations in the U.S.

Column	B
Format	Decimal Latitude
Units	N/A
Limitations	Value must be positive representing a location in the northern hemisphere
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.2.3 Longitude

The longitude of each facility to be included in the model. The model is currently only designed to be used for locations in the U.S.

Column	C
Format	Decimal Longitude
Units	N/A
Limitations	Value must be negative, representing a location in the western hemisphere
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.2.4 Region

The region of the U.S. the facility is located. See Appendix A for a list of which states are considered to be in the eastern and western U.S.

Column	D
Format	text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	Lookup in Appendix A based on state facility is located

2.2.2.5 .Sector

The sector the facility is located in. See definitions for general sector definitions based on EPA's mandatory greenhouse gas reporting rule.

Column	E
Format	text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.2.6 Leak Emission Data Sources

The source of data to estimate fugitive equipment leak probabilities and emission rates. User Specified data sources will need to create a data source file. Data source file set up is addressed in section 2.3.1 of this manual.

Column	F
Format	text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	• Production Facilities: "U.S. EPA Greenhouse Gas Reporting Program (GHGRP)" • Gathering and Boosting Facilities: "Gathering Compressor Station Study (CSU)" • Processing Facilities: "U.S. EPA Greenhouse Gas Reporting Program (GHGRP)" • Transmission and Storage Facilities: "Transmission and Storage Compressor Station Study (CSU)"

2.2.2.7 Leak Survey Method

The leak survey method used at the facility; only applicable if U.S. EPA Greenhouse Gas Reporting Program (GHGRP) is used for the leak emission data source.

Column	G
Format	text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Leak Emission Data Source is "U.S. EPA Greenhouse Gas Reporting Program (GHGRP)"
Optional if	N/A

Suggested Default	• If Method 21 is used under 40 CFR 60 Subpart OOOOa: "Method 21 as specified in §60.5397a" • Leak detection program is not in place, unknown, or not conducted under Subpart OOOOa: "OGI, Method 21, Infrared, or Acoustic"

2.2.2.8 Filename for User Specified Leaks

The file name of user specified leaks. Setting up this file is covered in Section 2.3.1 of this manual. This is only required if leak emission data source is "User Specified".

Column	H
Format	Excel file name (.xls .xlsx)
Units	N/A
Limitations	None
Required if	Leak Emission Data Source is "User Specified"
Optional if	N/A
Suggested Default	N/A

2.2.2.9 Pneumatic Data Source

The source of data for estimating emission rates from pneumatic devices.

Column	I
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	"Allen 2015 EF: Allen 2020 Abnormal Operations"

2.2.2.10 Reporting Year

The is the year of U.S. EPA Greenhouse Gas Reporting Program data that is used for the model.

Column	J
Format	YYYY
Units	Year
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	Same year or closest year to the Simulation Start Date in the Global_Simulation_Parameters

2.2.2.11 Composition Profile ID

The ID of the composition profile from the Composition sheet.

Column	K
Format	text
Units	N/A
Limitations	Must match one of the Composition Profile IDs in the Composition sheet
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.3 Composition

This sheet specifies the composition of emissions from each facility. A single composition may be applied to multiple facilities. Production facilities may have one composition per well thus multiple compositions for one facility. All other sectors may only have one composition profile per facility.

Many of the values may fluctuate depending on several variables such as time of year and age of wells. If possible, this value should correspond to the measurement of this value during the time the model is run (see Simulation Start Date in Global_Simulation_Parameters). Some of the required inputs for specific wells or regions may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted as requirements for data quality vary.

2.2.3.1 Composition Profile ID

A unique ID for each composition profile. This ID cross references to the Composition Profile ID in the Facility_Lists sheet.

Column	A
Format	Text, number or a combination of both
Units	N/A
Limitations	none
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.3.2 Composition Data Source

The method used to calculate the composition of gas on the site. The "thermodynamics" option calculates different compositions for different sources (for example the composition of flash gas from storage tanks will be different from the actuation gas of a pneumatic device). For the other options a single composition will be used for all sources at a site.

Column	B
Format	Text
Units	N/A

Limitations	Must be one of the options in the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	• Production Facilities: “thermodynamics” • Gathering and Boosting Facilities : “user specified” • Processing Facilities: “user specified” • Transmission and Storage Facilities: “Cardoso 2019 correlation”

2.2.3.3 Condensate (or OIL formation)

If the formation is considered condensate or oil. If the formation is oil it will in general result in lower amount of flash emissions from the storage tanks.

Column	C
Format	Yes or No
Units	N/A
Limitations	Must be one of the options in the drop-down list
Required if	Composition data source is “thermodynamics”
Optional if	N/A
Suggested Default	Two or more stage of gas/hydrocarbon separation: “yes” Stock Tank API Gravity of 38 or less: “no”

2.2.3.4 Number of Separator Stages

If the formation is oil (i.e. column C is set to “no”) the number of separator stages must be 1.

Column	D
Format	Integer
Units	N/A
Limitations	1 or 2 Must be 1 if Condensate (or OIL formation) is “no”
Required if	Composition data source is “thermodynamics”
Optional if	N/A
Suggested Default	• Number of stages of separation is one or unknown: “1” • Number of stages is two or more: “2”

2.2.3.5 API Gravity

The API gravity[1] (i.e. specific gravity) of the stock tank condensate. A higher API gravity tends to yield more methane emissions from the storage tank source. This value may fluctuate over time and may be publicly available from an oil and gas regulator.

Column	E
Format	Number
Units	Degrees API
Limitations	Must be between 38 and 62.8 degrees API
Required if	Composition data source is "thermodynamics" and Condensate (or OIL formation) is "yes"
Optional if	N/A
Suggested Default	Look up from state regulator (see appendix C)

2.2.3.6 Gas to Oil Ratio

The ratio of gas volume produced to stock tank oil volume produced. This value may fluctuate over time and may be publicly available from an oil and gas regulator.

Column	F
Format	Number
Units	standard cubic foot per petroleum barrel (scf/bbl)
Limitations	Must be between 477 scf/bbl and 58,200 scf/bbl
Required if	Composition data source is "thermodynamics" and Condensate (or OIL formation) is "yes"
Optional if	N/A
Suggested Default	Calculated from production data from state regulator (see appendix C)

2.2.3.7 Temperature

The temperature of the separator(s) at the facility. This value may fluctuate over time. A lower temperature tends to yield higher methane emissions from the storage tanks. If multiple separators are on site and they operate at different temperatures it is recommended the temperature of the last stage of separation be used.

Column	G
Format	Number
Units	Degrees Fahrenheit (°F)
Limitations	Must be between 20 °F and 120 °F
Required if	Composition data source is "thermodynamics"
Optional if	N/A
Suggested Default	N/A

[1] API Gravity may be calculated from specific gravity (1=water) using the following formula:
API Gravity=141.5/(SG-131.5)

2.2.3.8 1st Stage Pressure

The average pressure of the first stage of separation at the facility. This value may fluctuate over time. A higher pressure tends to yield higher methane emissions from the storage tanks.

Column	H
Format	Number
Units	Pounds per Square Inch Absolute (psia)
Limitations	Must be between 80 psia and 1,400 psia
Required if	Composition data source is "thermodynamics"
Optional if	N/A
Suggested Default	N/A

2.2.3.9 2nd Stage Pressure

The average pressure of the second stage of separation at the facility. If the facility has more than two stages of separation this should instead be the pressure of the last stage of separation. This value may fluctuate over time. A higher pressure tends to yield higher methane emissions from the storage tanks. This field is only required if the composition data source is "thermodynamics" and Number of Separator Stages is "2".

Column	I
Format	Number
Units	Pounds per Square Inch Absolute (psia)
Limitations	Must be between 20 psia and 380 psia
Required if	Composition data source is "thermodynamics" and Number of Separator Stages is "2"
Optional if	N/A
Suggested Default	N/A

2.2.3.10 Methane

The average mole fraction of methane in the sales gas. This value may fluctuate over time and may be publicly available from an oil and gas regulator.

Column	J
Format	Number
Units	Moles of methane per moles of gas (molar fraction)
Limitations	Must be less than 1 If Composition Data Source is "thermodynamics" must be between 0.58 and 0.90
Required if	Always
Optional if	N/A
Suggested Default[2]	User Specified value is preferred but if value is unknown: • Production: "0.79"

[2] From U.S. EPA Natural Star Program

	• Gathering and Boosting: “0.79” • Processing: “0.82” • Transmission and Storage: “0.94”

2.2.3.11 Ethane

The average mole fraction of ethane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	K
Format	Number
Units	Moles of ethane per moles of gas (molar fraction)
Limitations	Must be less than 1 If Composition Data Source is “thermodynamics” must be between 0.028 and 0.159
Required if	Composition data source is “user specified”
Optional if	Composition data source is “thermodynamics”
Suggested Default	None

2.2.3.12 Propane

The average mole fraction of Propoane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	L
Format	Number
Units	Moles of propane per moles of gas (molar fraction)
Limitations	Must be less than 1 If Composition Data Source is “thermodynamics” must be between 0.0087 and 0.0800
Required if	Composition data source is “user specified”
Optional if	Composition data source is “thermodynamics”
Suggested Default	None

2.2.3.13 Butane

The average mole fraction of butane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	M
Format	Number
Units	Moles of propane per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.14 Isobutane

The average mole fraction of isobutane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	N
Format	Number
Units	Moles of isobutane per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.15 Pentane

The average mole fraction of pentane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator. Other pentanes such as neopentane should be grouped with normal pentane and entered here.

Column	O
Format	Number
Units	Moles of pentane per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.16 Isopentane

The average mole fraction of isopentane in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	P
Format	Number
Units	Moles of isopentane per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.17 Hexane

The average mole fraction of hexanes and heavier hydrocarbons in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator. All hexanes and hydrocarbons heavier than hexane should be grouped and entered here.

Column	Q

Format	Number
Units	Moles of hexane+ per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.18 CO2

The average mole fraction of carbon dioxide in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	R
Format	Number
Units	Moles of carbon dioxide per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.19 N2

The average mole fraction of nitrogen in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	S
Format	Number
Units	Moles of nitrogen per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.3.20 H2S

The average mole fraction of hydrogen sulfide in the sales gas. This value may fluctuate over time and may be publicly available for an oil and gas regulator.

Column	R
Format	Number
Units	Moles of hydrogen sulfide per moles of gas (molar fraction)
Limitations	Must be less than 1
Required if	Composition data source is “user specified”
Optional if	N/A
Suggested Default	None

2.2.4 Wells

This sheet specifies well level data and includes data related to completions, production, well liquids unloading, separator dump events, pneumatic controllers and chemical injection pumps. Note that this sheet is not used if the user is not modeling any production facilities. If column A of any row is blank the entire row must be clear of all data including formulas.

2.2.4.1 Well_ID

This a unique well ID for each well to be modeled. This can be the well name or number such as the API number. Well names can be repeated if they are associated with separate sites. For example there can be a Well_1 associated with Facility_1 and a Well_1 associated with Facility_2 on the sheet.

Column	A
Format	Text or number
Units	N/A
Limitations	None
Required if	Always
Optional if	N/A
Suggested Default	None

2.2.4.2 Facility_ID

Column B – See Facility_ID Section 2.2.2.1. This value must match one of the Facility_IDs listed on the Facility_List sheet.

2.2.4.3 Composition Profile ID

The composition of the gas from the well. The Composition Profile ID must match one of the Composition Profile ID's in the Composition sheet.

Column	C
Format	Text or number
Units	N/A
Limitations	Must match a Composition Profile ID in the Composition sheet
Required if	Always
Optional if	N/A
Suggested Default	None

2.2.4.4 FIPS County Identifier

Auto-filled value based on the County selected in column E. If there is no formula in the cell it may be copied fromthe cell directly above or from cell C2 of InternalUseOnly_FeedbackFormula sheet.

Column	D
Format	Auto-filled
Units	N/A

Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	Auto-filled

2.2.4.5 County

The U.S. County where the well is located.

Column	E
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.4.6 Decline Curve Data Source

Oil and gas well production rates will decrease over time or decline. In order to determine the production at a specific point in time a decline curve is used. More on developing a well specific, user specified decline curve is discussed later in this document. Production over time for specific wells or regions may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted as requirements for data quality vary.

Column	F
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	"EIA National Energy Modeling Systems 2017"

2.2.4.7 Shale Play Name EIA NEMS

The shale play where the well is located. The EIA NEMS does not include all U.S. shale plays. A list of counties included in each play is provided in Appendix D. If the shale play for the well is not listed a representative one may be used. A list of typical production characteristics for the plays included are provided in Appendix C in order to aid in determining representativeness.

Column	G
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list

Required if	Decline Curve Data Source is "EIA National Energy Modeling Systems 2017"
Optional if	N/A
Suggested Default	N/A

2.2.4.8 Gas or Oil Well

If the well is considered a gas or oil well. Note that if "oil" is selected the model will not include liquid unloading

Column	H
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Decline Curve Data Source is "EIA National Energy Modeling Systems 2017"; or Pneumatic Controller Activity Factor Data Source is "U.S. EPA Greenhouse Gas Reporting Program (GHGRP)"; or Chemical Injection Pump Activity Factor Data Source is "U.S. EPA Greenhouse Gas Reporting Program (GHGRP)"
Optional if	N/A
Suggested Default	• "Gas" if liquid unloading is conducted on the well regardless of the shale play • "Oil" if Shale Play Name EIA NEMS is "Bakken", Woodford", "Spraberry" or "Wolfcamp" • "Gas" if Shale Play Name EIA NEMS is "Barnett", "Eagle Ford", Fayetteville", "Haynesville-Bossier", "Marcellus", or "Utica"

2.2.4.9 Gas Production at start of simulation

The natural gas production rate at the simulation start date (see Global_Simulation_Parameters). Production for specific wells or regions may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted as requirements for data quality vary.

Column	I
Format	Number
Units	Thousand standard cubic feet per day (Mscf/day)
Limitations	None
Required if	Decline Curve Data Source is "EIA National Energy Modeling Systems 2017"
Optional if	N/A
Suggested Default	Date from state regulator

2.2.4.10 Oil Production at start of simulation

The oil production rate at the simulation start date (see Global_Simulation_Parameters). Production for specific wells or regions may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted as requirements for data quality vary. This value should be left blank if it is a dry gas well that does not produce any oil or condensate.

Column	J
Format	Number
Units	Petroleum barrels per day (bbl/day)
Limitations	None
Required if	Decline Curve Data Source is "EIA National Energy Modeling Systems 2017"
Optional if	N/A
Suggested Default	Data from state regulator

2.2.4.11 Water Production at start of simulation

The water production rate at the simulation start date (see Global_Simulation_Parameters). Production for specific wells or regions may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted as requirements for data quality vary.

Column	K
Format	Number
Units	Petroleum barrels per day (bbl/day)
Limitations	None
Required if	Decline Curve Data Source is "EIA National Energy Modeling Systems 2017"
Optional if	N/A
Suggested Default	Data from state regulator

2.2.4.12 Last Completion Date

The date the well was last completed or recompleted. This date may be publicly available from a state's oil and gas regulator. A list of regulators in select states can be found in Appendix C. Careful review of the data should be conducted. Recompletions especially may not be available from the regulator.

Column	L
Format	MM/DD/YYY
Units	Date
Limitations	None
Required if	Always
Optional if	N/A
Suggested Default	Data from state regulator

2.2.4.13 Decline Q_i oil

The initial oil production rate of the well. This value should be developed based on actual observed production data. Information on how to develop this value is discussed later in this document in section 2.3.3. This value should be left blank if it is a dry gas well that does not produce any oil or condensate.

Column	M
Format	Number
Units	Petroleum barrels per day (bbl/day)
Limitations	None
Required if	Decline Curve Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown use “EIA National Energy Modeling Systems 2017” for Decline Curve Data Source

2.2.4.14 Decline Q_i gas

The initial gas production rate of the well. This value should be developed based on actual observed production data. Information on how to develop this value is discussed later in this document in section 2.3.3.

Column	N
Format	Number
Units	Thousand standard cubic feet per day (Mscf/day)
Limitations	None
Required if	Decline Curve Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown use “EIA National Energy Modeling Systems 2017” for Decline Curve Data Source

2.2.4.15 Decline Q_i water

The initial water production rate of the well. This value should be developed based on actual observed production data. Information on how to develop this value is discussed later in this document in section 2.3.2.

Column	O
Format	Number
Units	Petroleum barrels per day (bbl/day)
Limitations	None
Required if	Decline Curve Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown use “EIA National Energy Modeling Systems 2017” for Decline Curve Data Source

2.2.4.16 Decline D_i

The initial decline rate. This should be developed based on actual observed production data. Information on how to develop this value is discussed later in this document in section 2.3.2.

Column	P
Format	Number
Units	Petroleum barrels per day (bbl/day) 1 / month
Limitations	None
Required if	Decline Curve Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown use “EIA National Energy Modeling Systems 2017” for Decline Curve Data Source

2.2.4.17 Decline b hyperbolic

The hyperbolic parameter or the degree of curvature of the line. This should be developed based on actual observed production data. Information on how to develop this value is discussed later in this document in section 2.3.2.

Column	Q
Format	Number
Units	unitless
Limitations	None
Required if	Decline Curve Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown use “EIA National Energy Modeling Systems 2017” for Decline Curve Data Source

2.2.4.18 Unloading Activity Factor Data Source

The source of the well liquids unloading method. If the specific unloading method is known, including those wells without unloading, “None (fully specified)” should be used.

Column	R
Format	Text
Units	N/A
Limitations	Must be a value from the drop-down list
Required if	Always
Optional if	N/A
Suggested Default	“U.S. EPA Greenhouse Gas Reporting Program (GHGRP)”

2.2.4.19 Basin ID GHGRP AAPG

The American Association of Petroleum Geologists basin ID. This is auto-filled based on basin name selected in column T . If there is no formula in the cell it may be copied from the cell directly above or from cell C3 of InternalUseOnly_FeedbackFormula sheet.

Column	S
Format	Number
Units	N/A
Limitations	Auto-Populated based on Basin Name
Required if	Unloading Activity Factor Data Source is “U.S. EPA Greenhouse Gas Reporting Program (GHGRP)”
Optional if	N/A
Suggested Default	N/A

2.2.4.20 Basin Name AAPG

The American Association of Petroleum Geologists basin name where the well is located. A map of geologic basins can be found at https://ngmdb.usgs.gov/Geolex/stratres/provinces

Column	T
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Unloading Activity Factor Data Source is “U.S. EPA Greenhous Gas Reporting Program (GHGRP)”
Optional if	N/A
Suggested Default	N/A

2.2.4.21 Formation Type

The type of formation that the well produces from. Most formations that use horizontal drilling and hydraulic fracturing would be considered unconventional.

Column	U
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Unloading Activity Factor Data Source is “U.S. EPA Greenhous Gas Reporting Program (GHGRP)”
Optional if	N/A
Suggested Default	“unconventional”

2.2.4.22 Unloading technology

The unloading technology used for the well. “none” should be specified for wells that do not conduct liquids unloading and for wells that use liquid unloading technology but produce unloaded liquids through normal production equipment.

Column	V
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list

Required if	Unloading Activity Factor Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown “U.S. EPA Greenhouse Gas Reporting Program (GHGRP)” should be selected for Unloading Activity Factor Data Source

2.2.4.23 Unloading Properties Data Source

The source of the unloading event properties including duration, frequency and vent rate. “None (fully specified)” should only be used if all the unloading properties in column X through AC are known. If “Allen 2015, Allen 2020; Timing from log by user” is used the timing log for unloading in the Wellpad_UnloadingTiming sheet must be completed for the well. “Allen 2015, Allen 2020; Timing Vaughn 2018” times the well unloading so that unloadings occur during daylight hours.

Column	W
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“Allen 2015, Allen 2020”

2.2.4.24 Unloading frequency

The number of unloading events that occur at the well during a one-year period. Unloading events may increase as the well ages. If possible, this value should correspond to the number of unloading events during the time the model is run (see Simulation Start Date in Global_Simulation_Parameters sheet)

Column	X
Format	Number
Units	Events per year
Limitations	N/A
Required if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.25 Unloading shut-in duration

The amount of time the well is shut-in between unloading events. The shut-in time may increase as the well ages. If possible, this value should correspond to the shut-in duration during the time the model is run (see Simulation Start Date in Global_Simulation_Parameters sheet)

Column	Y

Format	Number
Units	Seconds
Limitations	N/A
Required if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.26 Unloading venting duration

The amount of time the well is vented during an unloading event. The amount of time may vary as the well ages. If possible, this value should correspond to the venting duration during the time the model is run (see Simulation Start Date in Global_Simulation_Parameters sheet)

Column	Z
Format	Number
Units	Seconds
Limitations	N/A
Required if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020” or “Allen 2015, Allen 2020; Timing from log by user”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.27 Unloading wholegas

The amount of gas that is vented during an unloading event. The amount may vary as the well ages. If possible, this value should correspond to the vent rate during the time the model is run (see Simulation Start Date in Global_Simulation_Parameters sheet)

Column	AA
Format	Number
Units	Standard cubic feet per event (scf/event)
Limitations	N/A
Required if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020” or “Allen 2015, Allen 2020; Timing from log by user”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.28 Unloading onset

The age of the well (in months) when unloading first began. For example, if unloading began 1 year after first production, the value entered would be 12.

Column	AB
Format	Number
Units	months
Limitations	N/A
Required if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “no plunger”, “plunger manual” or “plunger auto” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020” or “Allen 2015, Allen 2020; Timing from log by user”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.29 Unloading Start time of day

The time of day that unloading typically begins for manual unloading.

Column	AC
Format	Time, hh:mm:ss
Units	Time of day
Limitations	N/A
Required if	Unloading Technology is “plunger manual” AND Unloading Activity Properties Data Source is “None (fully specified)”
Optional if	Unloading Technology is “plunger manual” AND Unloading Activity Properties Data Source is “Allen 2015, Allen 2020” or “Allen 2015, Allen 2020; Timing from log by user”
Suggested Default	If Unknown, “Allen 2015, Allen 2020” should be selected for Unloading Properties Data Source

2.2.4.30 Completion Emission Factor Data Source

The source of emission factors used for well completion activities. “None (fully specified)” should only be used if the total amount of methane emitted during the completion is known.

Column	AD
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“Allen 2013 Measured emission”

2.2.4.31 Completion Timeseries Data Source

The duration and potential variation in emissions that occur during a completion. “None (fully specified)” and “Duration sampled from Allen 2013, Fixed rate” assumes the emission rate is constant during the completion period. “Two stage duration with temporal variation from Allen 2013” varies the emission rate over the completion period.

Column	AE
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“Duration sampled from Allen 2013, Fixed rate”

2.2.4.32 Completion Timeseries Data Source

The duration and potential variation in emissions that occur during a completion. “None (fully specified)” and “Duration sampled from Allen 2013, Fixed rate” assumes the emission rate is constant during the completion period. “Two stage duration with temporal variation from Allen 2013” varies the emission rate over the completion period.

Column	AE
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“Duration sampled from Allen 2013, Fixed rate”

2.2.4.33 Completion methane

The amount of methane (in kg) emitted during completion of the well.

Column	AF
Format	Number
Units	Kilograms per event (kg/event)
Limitations	N/A
Required if	Completion Emission Factor Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown, an option other than “None (fully specified)” should be used for the Completion Emission Factor Data Source

2.2.4.34 Completion duration

The amount of time it takes to complete the well, in hours.

Column	AG
Format	Number
Units	Hours
Limitations	N/A
Required if	Completion Timeseries Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	If unknown, an option other than “None (fully specified)” should be used for the Completion timeseries Data Source

2.2.4.35 Tank Flash Properties Data Source

Oil, condensate, and water is typically transferred in batches or dump events from the separators to the storage tanks. This is the source of dump volume, duration, and frequency. “None (fully specified)” should only be selected if the dump event volume, duration and how long into the dump event the peak occurs are all known. “Dump volume user specified; Timing CAMS-MEET 2020” can be used if the dump volume is known.

Column	AH
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“CAMS-MEET 2020”

2.2.4.36 Pneumatic Controller Activity Factor Data Source

The source of the number and type of pneumatic controllers associated with the well. “None (fully specified)” can be used to specify the number and type of pneumatic controller associated with the well in the Wellpad_Pneumatics sheet. If the facility uses electric or instrument air powered device only, “None (fully specified)” should be used and no controllers should be entered into the Wellpad_Pneumatics sheet.

Column	AI
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list Must be “None (fully specified)” if Pneumatic Controller Emission Factor Data Source is “None (fully specified)”
Required if	Always
Optional if	N/A
Suggested Default	“U.S. EPA Greenhouse Gas Reporting Program (GHGRP)”

2.2.4.37 Pneumatic Controller Emission Factor Data Source

The source of the emission factor for pneumatic devices. “None (fully specified)” can be used to specify the emissions rate from each pneumatic controller in the Wellpad_Pneumatics sheet. “None (fully specified)” can only be used if the Pneumatic Controller Activity Factor Data Source is also set to “None (fully specified)”. If the facility uses electric or instrument air powered device only, “None (fully specified)” should be used and no controllers should be entered into the Wellpad_Pneumatics sheet.

Column	AJ
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	“Allen 2015 EF; Allen 2020 Abnormal Operation”

2.2.4.38 Chemical Injection Pump Activity Factor Data Source

The source of the number of chemical injection pumps associated with the well. “None (fully specified)” can be used to manually enter each pump associated with the well in the Wellpad_ChemicalInjectionPump sheet. If the facility uses electric or instrument air powered pumps only, “None (fully specified)” should be used and no controllers should be entered into the Wellpad_ChemicalInjectionPump sheet.

Column	AK
Format	Text
Units	N/A
Limitations	Must be a value from the drop down list Must be “None (fully specified)” if Chemical Injection Pump Emission Factor Data Source is “None (fully specified)”
Required if	Always
Optional if	N/A
Suggested Default	“U.S. EPA Greenhouse Gas Reporting Program (GHGRP)”

2.2.4.39 Chemical Injection Pump Emission Factor Data Source

The source of the emission factor for chemical injection pumps. “None (fully specified)” can be used to specify the emissions rate from each pump in the Wellpad_ChemicalInjectionPump sheet. “None (fully specified)” can only be used if the Chemical Injection Pump Activity Factor Data Source is also set to “None (fully specified)”. If the facility uses electric or instrument air powered device only, “None (fully specified)” should be used and no controllers should be entered into the Wellpad_ChemicalInjectionPump sheet.

Column	AL
Format	Text

Units	N/A
Limitations	Must be a value from the drop down list
Required if	Always
Optional if	N/A
Suggested Default	"Allen 2013 EF"

2.2.5 Wellpad_Unloading Timing

This sheet specifies specific well unloading events. It is only required to be filled out if Unloading Properties Data Source in the Wells sheet is set to "Allen 2015, Allen 2020; Timing from log by user." Only the events that occur during the time the model is run (see Simulation Start Date and Simulation duration in Global_Simulation_Parameters sheet) need to be entered. Wells may have multiple entries representing multiple unloading events depending on the duration of the simulation. If column A of a row is blank the entire row must clear of all data including formulas. If "Allen 2015, Allen 2020; Timing from log by user" is not used for the unloading property data source for any of the wells or production facilities not being modeled this sheet will be blank (other than titles). Well_ID

2.2.5.1 Well_ID

Column A – See Well_ID Section 2.2.4.1. This value must match one of the Well_IDs listed on the Wells sheet.

2.2.5.2 Facility_ID

Column B – See Facility_ID Section 2.2.2.1. This value must match one of the Facility_IDs listed on the Facility_List sheet and must match the facility associated with the well in the Wells Sheet.

2.2.5.3 Venting Start DateTime

The time venting began for an unloading event.

Column	C
Format	Excel Date and Time, yyyy-mm-dd hh:MM:ss
Units	Point in time
Limitations	N/A
Required if	Any well with Unloading Properties Data Source in the Wells sheet set to "Allen 2015, Allen 2020; Timing from log by user."
Optional if	N/A
Suggested Default	If start date is unknown Unloading Properties Data Source in the Wells sheet should be set to "Allen 2015, Allen 2020"

2.2.5.4 Venting Duration

The duration, in hours, of the venting from the well unloading event.

Column	D
Format	Number
Units	hours

Limitations	None
Required if	Any well with Unloading Properties Data Source in the Wells sheet set to “Allen 2015, Allen 2020; Timing from log by user.”
Optional if	N/A
Suggested Default	If duration is unknown Unloading Properties Data Source in the Wells sheet should be set to “Allen 2015, Allen 2020”

2.2.5.5 Shut in Duration prior to venting

The amount of time, in hours, that the well was shut-in before the unloading event occurred.

Column	E
Format	Number
Units	hours
Limitations	None
Required if	Never
Optional if	Any well with Unloading Properties Data Source in the Wells sheet set to “Allen 2015, Allen 2020; Timing from log by user.”
Suggested Default	Leave blank if shut in duration is unknown since value is optional

2.2.6 Wellpad_Tank Flash

Oil, condensate, and water will release gas as the pressure of the liquid decreases when it is transferred from the separator to the storage tanks. This sheet is used to determine the duration and frequency of flashing due to dump events. This sheet only needs to be completed if any of the wells have a Tank Flash Properties Data Source in the Wells sheet that is set to “None (fully specified)” or “Dump volume user specified; Timing CAMS-MEET 2020.” This sheet corresponds to fluid production (water and/or oil), not to the configuration of tanks vs. Wells. For example, if 5 wells feeds condensate to one tank (or however many), there should be 5 records, one row for each well. A record is needed only for the type of fluid produced by each well. For example, a gas well may only produce water and gas and not produce any condensate and. In such case, only a row for water production is needed.

2.2.6.1 Tank_ID

This is a unique tank ID for each tank to be modeled.

Column	A
Format	Text or number
Units	N/A
Limitations	None
Required if	Always
Optional if	N/A
Suggested Default	None

2.2.6.2 Well_ID

Column B – See Well_ID Section 2.2.4.1. This value must match one of the Well_IDs listed on the Wells sheet.

2.2.6.3 Facility_ID

Column C – See Facility_ID Section 2.2.2.1. This value must match one of the Facility_IDs listed on the Facility_List sheet and must match the facility associated with the well in the Wells Sheet.

2.2.6.4 Tank Fluid Type

This is the type of fluid that will be flowing into the tanks. For most wells, there will be a condensate/oil tank and a water tank for the same Well_ID and Facility_ID.

Column	D
Format	Text
Units	N/A
Limitations	Drop-down list
Required if	Always
Optional if	N/A
Suggested Default	None

2.2.6.5 Tank Flash Properties Data Source

This is auto-filled based on the Well_ID and Tank Flash Properties Data Source selected for the specific well in the Wells sheet. If there is no formula it may be copied from an above row or from cell C6 of InternalUseOnly_FeedbackFormula sheet.

2.2.6.6 Dump Volume

This is the volume in petroleum barrels (bbl) that is transferred from the separators to the tanks by a single dumping event.

Column	F
Format	Number
Units	bbl/event
Limitations	N/A
Required if	Column E is either “None (Fully Specified)” or “Dump volume user specified; Timing CAMS-MEET 2020”
Optional if	N/A
Suggested Default	None

2.2.6.7 Dump Duration

This is the amount of time in seconds that is takes a single dump event to complete the transfer from the separator to the tank.

Column	G
Format	Number
Units	Seconds

Limitations	N/A
Required if	Column E is “None (Fully Specified)”
Optional if	N/A
Suggested Default	N/A

2.2.6.8 Dump Peak Timing

This is the amount of time in seconds it takes for the dump event to reach its maximum flow rate. Liquid flow rate is assumed to change in triangular manner, increase from zero linearly to the peak rate and then decrease to zero linearly.

Column	H
Format	Number
Units	Seconds
Limitations	Must be less than Dump Duration
Required if	Column E is “None (Fully Specified)”
Optional if	N/A
Suggested Default	One half of the dump duration: (½ * Dump Duration)

2.2.7 Wellpad_Pneumatics

Wellpad Pneumatics is set up to provide the ability to specify how each pneumatic controller behaves. This is generally an advanced approach and requires the user to know the number of each type of device associated with each well. Wells where “None (fully specified)” is selected for the Pneumatic Controller Activity Factor in the Wells sheet should have at least one entry unless the well has no natural gas actuated pneumatic controllers associated with it. Wells will likely have multiple entries representing multiple associated pneumatic devices. If column A of a row is blank the entire row must be clear of all data including formulas. If “None (fully specified)” is not used for the Pneumatic Controller Activity Factor for any of the wells or no production facilities are included in the model, this sheet will be blank (other than titles).

2.2.7.1 Pneumatics_ID

This is a unique identifier used for EACH natural gas pneumatic controller. Each pneumatic controller at the facility will need a unique identifier.

Column	A
Format	Text or Number
Units	N/A
Limitations	N/A
Required if	Column D – Pneumatic Controller Activity Factor Data Source is “None (fully specified)”
Optional if	N/A
Suggested Default	N/A

2.2.7.2 Well_ID

Column C – See Well_ID Section 2.2.4.1. This value must match one of the Well_IDs listed on the Wells sheet.

2.2.7.3 Facility_ID

Column C– See Facility_ID Section 2.2.2.1. This value must match one of the Facility_IDs listed on the Facility_List sheet and must match the facility associated with the well in the Wells Sheet.

2.2.7.4 Pneumatic Controller Activity Factor Data Source

Column D - The Pneumatic Controller Activity Factor Data Source. This column is auto-populated based on the Well_ID entered in column B and the Pneumatic Controller Activity Factor Data Source for the well entered in the Wells Sheet. If there is no formula it may be copied from an above row or from cell C8 of InternalUseOnly_FeedbackFormula sheet.

2.2.7.5 Pneumatic Controller Emission Factor Data Source

Column E - The Pneumatic Controller Emission Factor Data Source. This column is auto-populated based on the Well_ID entered in column B and the Pneumatic Controller Emission Factor Data Source for the well entered in the Wells sheet. If there is no formula it may be copied from an above row or from cell C9 of InternalUseOnly_FeedbackFormula sheet.

2.2.7.6 Pneumatic Device Subtype

The Pneumatic Device Subtype sets the emission rate of the controller as well as the behavior of the device.

Intermittent Controller: This device vents motive gas intermittently, typically when the device actuates

Lowbleed Controller: This device continuously vents motive gas at a rate of less than or equal to 6 standard cubic feet per hour (≤6 scfh) as provided in the manufacturer's literature.

Highbleed Controller: This device continuously vents motive gas at a rate that is greater than 6 cubic feet per hour (>6 scfh) as provided in the manufacturer's literature.

Column	F
Format	Text
Units	N/A
Limitations	Drop-down List
Required if	Always – Unless Pneumatic Controller Emission Factor Data Source is "None"
Optional if	N/A
Suggested Default	Intermittent Controller Diaphragm Pump

2.2.7.7 Pneumatic Emission Model

Each pneumatic device may be modeled one of two ways, with a single fixed emission rate, or with normal and abnormal emission rates.

Fixed Emission Rate: Requires the user to input only the "normal" emission rate for that pneumatic device.

Two-States: Requires the user to input all of the information in columns H-K for the pneumatic device.

Column	G
Format	Text
Units	N/A
Limitations	Drop-down List
Required if	Always – Unless Pneumatic Controller Emission Factor Data Source is "None"
Optional if	N/A
Suggested Default	Intermittent

2.2.7.8 Normal Emission Rate

This is the emission rate of the pneumatic device, in standard cubic feet per hour (scfh), when it is operating as designed or as the manufacturer intended.

Note: For intermittent devices, this represents the total emissions over the course of an hour, NOT the short-term emission flow rate at the time of the event.

Column	H
Format	Number
Units	scfh
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.7.9 Abnormal Emission Rate

This is the emission rate of the pneumatic device, in standard cubic feet per hour (scfh), when it is not operating as designed or as the manufacturer intended.

Note: For intermittent devices, this represents the total emissions over the course of an hour, NOT the short-term emission flow rate at the time of the event.

Column	I
Format	Number
Units	Scfh
Limitations	N/A

Required if	Pneumatic Emission Model "Two States (Normal/Abnormal) with constant MTTR and Abnormal Fraction" is selected in column G
Optional if	N/A
Suggested Default	N/A

2.2.7.10 Fraction of Abnormally Operating Device

This is the fraction of time where the device is considered to be operating abnormally. This typically requires an inspection program to be in place. The fraction of time considered to be abnormal is the ratio of inspections in which the result was found to be abnormal divided by the total number of inspections.

Note: To the extent practicable, device operating data for the specific time period should be used for the simulation.

Example: Annual inspections revealed that one device out of 100 inspected was operating abnormally. The value entered would be 1/100 or 0.01.

Column	J
Format	Number
Units	Dimensionless
Limitations	Must be less than 1.0
Required if	Pneumatic Emission Model "Two States (Normal/Abnormal) with constant MTTR and Abnormal Fraction" is selected in column G
Optional if	N/A
Suggested Default	0.08, based on numbers of intermittent controllers found to have abnormal emissions at well sites in a US nation-wide study at well sites with measurements conducted in 2014

2.2.7.11 Mean Time To Repair (MTTR)

This is the average amount of time it takes from the point at which the abnormal operation begins, to the point when the device is considered to be operating normally again.

Column	K
Format	Number
Units	Hours
Limitations	N/A
Required if	Pneumatic Emission Model "Two States (Normal/Abnormal) with constant MTTR and Abnormal Fraction" is selected in column G
Optional if	N/A
Suggested Default	N/A

2.2.8 Wellpad_ChemicalInjectionPump

This section only needs to be filled out for wells where the Chemical Injection Pump Activity Factor Data Source is "None (fully specified)".

2.2.8.1 Chemical Injection Pump_ID

This is a unique name or number for each natural gas driven chemical injection pump associated with the well. Each pump will need its own unique ID.

Column	A
Format	Text or Number
Units	N/A
Limitations	N/A
Required if	Chemical Injection Pump Activity Factor Data Source is "None (fully specified)"
Optional if	N/A
Suggested Default	N/A

2.2.8.2 Well_ID

Column B – See Well_ID Section 2.2.4.1. This value must match one of the Well_IDs listed on the Wells sheet.

2.2.8.3 Facility_ID

Column C – See Facility_ID Section 2.2.2.1. This value must match one of the Facility_IDs listed on the Facility_List sheet and must match the facility associated with the well in the Wells Sheet.

2.2.8.4 Chemical Injection Pump Activity Factor Data Source

Column D – This column is auto-populated based on the Well_ID entered in column B and the Chemical Injection Pump Activity Factor Data Source for the well entered in the Wells Sheet. If there is no formula it may be copied from an above row or from cell C11 of InternalUseOnly_FeedbackFormula sheet.

2.2.8.5 Chemical Injection Pump Emission Factor Data Source

Column E – This column is auto-populated based on the Well_ID entered in column B and the Chemical Injection Pump Emission Factor Data Source for the well entered in the Wells Sheet. If there is no formula it may be copied from an above row or from cell C12 of InternalUseOnly_FeedbackFormula sheet.

2.2.8.6 Methane Emission Rate

This is the Methane emission rate of the chemical injection pump.

Column	F
Format	Number
Units	kg/hr
Limitations	N/A
Required if	Chemical Injection Pump Activity Factor Data Source is "None (fully specified)"

Optional if	N/A
Suggested Default	N/A

2.2.9 Compressors

This sheet is to enter data related to natural gas compressors and their drivers. Each compressor must be listed in its own row.

2.2.9.1 Compressor_ID

This is a unique name or number for the natural gas compressors. Each natural gas compressor at the facility will require its own unique ID.

Column	A
Format	Text or Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.9.2 Facility_ID

Column B – See Facility_ID Section 2.2.2.1.

2.2.9.3 Compressor_Type

This is the type of natural gas compressor being used. Reciprocating compressors are most common in the Production and Gathering and Boosting sectors. Centrifugal compressors are more frequently found in the Processing and Transmission sectors.

Column	C
Format	Text
Units	N/A
Limitations	Drop-down list
Required if	Always
Optional if	N/A
Suggested Default	Reciprocating - Production and Gathering Boosting Centrifugal – Processing and Transmission

2.2.9.4 Data Source

This is the data source that will be used to determine emissions from compressor and compressor drivers. If “User Specified” is selected the file name for the user specified data must be provided in Column E.

Column	D
Format	Text
Units	N/A
Limitations	Drop-down list – User Specified must have data file
Required if	Always

Optional if	N/A
Suggested Default	Production - “U.S. EPA Greenhouse Gas Reporting Program (GHGRP)” Gathering and Boosting - “Gathering Compressor Station Study (CSU)” Processing/Transmission/Storage - “Transmission and Storage Compressor Station Study”

2.2.9.5 Filename for User Specified Data Source

This is the name of the file which will be called for the User Specified Data Source. The filename must contain the extension “.xlsx” and needs to be located in the input/CompressorModelData directory.

Column	E
Format	Text
Units	N/A
Limitations	Must have “.xlsx” file extension
Required if	Data Source is “User Specified”
Optional if	N/A
Suggested Default	compressor_leaks.xlsx

2.2.9.6 Combustion Emission Reference

This is the emission factor reference for the combustion exhaust emissions from the compressor driver.

Column	F
Format	Text
Units	N/A
Limitations	Drop-down List
Required if	Always
Optional if	N/A
Suggested Default	EPA AP-42

2.2.9.7 Driver Type

This is the classification of the prime mover of the compressor. Electric motors are typically used in relatively smaller applications (hundreds of horsepower), internal combustion engines are generally used for large application (thousands of horsepower). A Reciprocating Internal Combustion Engine (RICE) can utilize “two-stroke lean-burn”, “four-stroke lean-burn", or “four-stroke rich-burn” combustion strategies. Turbines should only be selected if it is a known turbine driven compressor.

Column	G
Format	Text
Units	N/A

Limitations	Drop-down List
Required if	N/A
Optional if	Always
Suggested Default	If driver is a known RICE use “Four-Stroke Lean-Burn" otherwise blank if unknown

2.2.9.8 Driver Size

This is the maximum manufacturer rated power of the compressor driver in brake horsepower (bhp).

Column	H
Format	Number
Units	Horsepower (bhp)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.9 Compressor Cylinders

This is the number of compression cylinders for reciprocating compressors. This is not applicable for centrifugal compressors.

Column	I
Format	Number
Units	Dimensionless
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.10 Seal Type

This is the type of seal used for a centrifugal compressor. There are generally two types of seals, “wet” and “dry” seals. Wet seals typically have a higher emission rate. If unknown this can be estimated from data distributions.

Column	J
Format	Text
Units	N/A
Limitations	Drop-down list
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.11 Fuel Consumption

This is the Brake-Specific Fuel Consumption (BSFC) in Bristish Thermal Units per Brake Horsepower-Hour (BTU/bhp-hr). This value should be based on full load and Gross Heating Value or Higher Heating Value (HHV) of the fuel. This information should be provided by the manufacturer.

Column	K
Format	Number
Units	British Thermal Units per break horsepower hour (BTU/bhp-hr)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.12 Average Loading

This is the average load on the compressor expressed in percent (%). It is the ratio of actual compressor horsepower divided by the manufacturer's maximum rated horsepower.

If left blank the following default values will be used, based on the industry sector:

- Production: 100%
- Gathering and Boosting: 83%
- Processing: 100%
- Transmission and Storage: 90%

Column	L
Format	Number
Units	%
Limitations	Must be less than or equal to 100
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.13 Loading Standard Deviation

This is the standard deviation of the compressor load. Standard deviation should be representative of the compressor operation during the period of time the model is run for, to the extent practicable.

Note: If "Average Loading" is populated with this cell left blank, there will be an assumed standard deviation of zero and the compressor will be modeled at the average loading.

If left blank the following default values will be used, based on the industry sector:

- Production: 0%
- Gathering and Boosting: 8.9%

- Processing: 0%
- Transmission and Storage: 1%

Column	M
Format	Number
Units	%
Limitations	Must be less than or equal to 100
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.14 OP Mode Hours per Year

This is the number of hours the compressor operates per year.

The Gathering Compressor Station Study did not collect data on hours per year spent in each operating mode. Therefore, if the Gathering Compressor Station Study data source is used, and this field is not provided by the user, a default value of 8,322 hours per year (corresponding to a 95% uptime) is used.

GHGRP does not collect any information on operating hours for compressors in the Production or Gathering and Boosting sectors. Instead, these compressors have a fixed, annualized emission factor. Therefore, if the GHGRP data source is used, and this value is not specified, these compressors will be "always on", e.g., 100% uptime.

Column	N
Format	Number
Units	Hours per year (hrs/yr)
Limitations	OP Mode Hours per Year, NOP Mode Hours per Year, and NOD Mode Hours per Year cannot all be zero
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.15 NOP Mode Hours per Year

This is the number of hours the compressor is not operating but remains pressurized.

The Gathering Compressor Station Study did not collect data on hours per year spent in each operating mode. Therefore, if the Gathering Compressor Station Study data source is used, and this field is not provided by the user, a default value of 219 hours per year (corresponding to 2.5% of the year) is used.

GHGRP does not collect any information on operating hours for compressors in the Production or Gathering and Boosting sectors. Instead, these compressors have a fixed, annualized emission factor. Therefore, if the GHGRP data source is used, and this value

is not specified, these compressors will be “always on”, e.g., NOP mode hours will be zero.

Column	O
Format	Number
Units	Hours per year (hrs/yr)
Limitations	OP Mode Hours per Year, NOP Mode Hours per Year, and NOD Mode Hours per Year cannot all be zero
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.16 NOD Mode Hours per Year

This is the number of hours the compressor is not operating and depressurized.

The Gathering Compressor Station Study did not collect data on hours per year spent in each operating mode. Therefore, if the Gathering Compressor Station Study data source is used, and this field is not provided by the user, a default value of 219 hours per year (corresponding to 2.5% of the year) is used.

GHGRP does not collect any information on operating hours for compressors in the Production or Gathering and Boosting sectors. Instead, these compressors have a fixed, annualized emission factor. Therefore, if the GHGRP data source is used, and this value is not specified, these compressors will be “always on”, e.g., NOP mode hours will be zero.

Column	P
Format	Number
Units	Hours per year (hrs/yr)
Limitations	OP Mode Hours per Year, NOP Mode Hours per Year, and NOD Mode Hours per Year cannot all be zero
Required if	N/A
Optional if	Compressor operation data can be obtained
Suggested Default	N/A

2.2.9.17 OP Mode Runtime

The expected minimum, average, and maximum time the compressor operates for each time it is started up. Or the operating time during each operating cycle. Enter as a list with commas separating each value (e.g. 1,420,720). This value may also be a single constant in which case the engine will always operate for that number of hours during each cycle. If a single number is entered the OP Mode Hours per Year is ignored.

If this is not specified, the following default values will be used:

- Min = 1
- Mean = 420
- Max = 720

Note: these default values do not apply to GHGRP compressors in the Production and Gathering sectors which are treated as “always on”.

Column	Q
Format	Min, Avg, Max or number
Units	Hours per cycle (hrs/cycle)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.18 NOP Mode Runtime

The expected minimum, average, and maximum time the compressor is not operating but pressurized each time the compressor is shut down. Enter as a list with commas separating each value (e.g. 0.5,8,24). This value may also be a constant, in which case the engine will always remain in the not operating pressurized (NOP) mode for exactly the same number of hours each time it enters that state. If a single number is entered the NOP Mode Hours per Year is ignored.

If this is not specified, the following default values will be used:

- Min = 0.5
- Mean = 8
- Max = 24

Note: these default values do not apply to GHGRP compressors in the Production and Gathering sectors which are treated as “always on”.

Column	R
Format	Min, Avg, Max or number
Units	Hours per cycle (hrs/cycle)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.19 NOD Mode Runtime

The expected minimum and maximum time the compressor remains in the not operating depressurized (NOD) state. Note that unlike OP and NOP, the average time is not specified; the average time is derived from other inputs. Enter as a list with a comma separating the two value. This value may also single number in which case the

engine will always be in non-operating non-pressure mode each time it is shutdown. If a single number is entered it the NOD Mode Hours per Year is ignored.

If this is not specified, the following default values will be used:

- Min = 0.5
- Max = 48

Note: these default values do not apply to GHGRP compressors in the Production and Gathering sectors which are treated as “always on”.

Column	S
Format	Min, Max or number
Units	Horus per cycle (hrs/cycle)
Limitations	Must be less than 8,760
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.20 Starter Vent Emission Volume

This is the volume of whole gas emitted during a typical engine startup.

Note: This is only applicable to engine which use gas as a starter motive fluid. Instrument air, electric starters, or other non-methane bearing sources of starting energy are not applicable and a value of “0” should entered.

Column	T
Format	Number
Units	Standard cubic feet per event (SCF/Event)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.21 Starter Vent Duration

This is the average amount of time in seconds that each starting event takes. If multiple attempts are needed to start the engine each time this value should be the sum of those attempts.

Column	U
Format	Number
Units	Seconds (s)
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.9.22 Blowdown Vent Emission Volume

This is the volume of whole gas, in standard cubic feet per event (scf/event), emitted during a typical compressor depressurization event.

Note: It is recommended that an estimate be entered as the default values from GHGRP have been found to be overestimate the volume and may not be representative of most operations.

Column	V
Format	Number
Units	scf/event
Limitations	N/A
Required if	N/A
Optional if	Compressor operation data can be obtained
Suggested Default	500

2.2.9.23 Blowdown Vent Duration

This is the amount of time that a blowdown event is expected to take in seconds.

Column	W
Format	Number
Units	Seconds
Limitations	N/A
Required if	N/A
Optional if	Compressor operation data can be obtained
Suggested Default	N/A

2.2.10 Dehydrators

This section is for entering information about glycol dehydration units. Desiccant dehydrators are not applicable to this section.

2.2.10.1 Dehydrator_ID

This is a unique name or number for each glycol dehydrator. Desiccant dehydrators are not applicable to this section and do not require an ID.

Column	A
Format	Text or Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.10.2 Facility_ID

Column B – See Facility_ID Section 2.2.2.1.

2.2.10.3 Throughput

This is the size of the dehydrator represented by natural gas throughput.

Column	C
Format	Number
Units	Million Standard Cubic Feet per day (MMscf/d)
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	≥0.4 MMscf/d

2.2.10.4 Vent to Flare

True or False regarding whether or not the dehydrator gas is sent to flare.

Column	D
Format	True/False
Units	N/A
Limitations	Drop-down List
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.10.5 Vent to Atmosphere

True or False regarding whether or not the dehydrator gas is vented to atmosphere.

Column	E
Format	True/False
Units	N/A
Limitations	Drop-down List
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.10.6 Flared Methane Emissions

This is the amount of methane emitted by the flare in metric tons per year. This is equal to the uncontrolled methane emissions estimated using a program such as GRI GlyCalc® multiplied by one minus the flare control efficiency. A typical flare control efficiency is 98%.

Example: 100 tpy * (1 - 0.98) = 2 tpy of methane.

Column	F

Format	Number
Units	Metric Tons per Year
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.10.7 Vented Methane Emissions

This is the amount of methane vented by the dehydrator in metric tons per year. This is equal to the uncontrolled methane emissions estimated using a program such as GRI GlyCalc®.

Column	G
Format	Number
Units	Metric Tons per Year
Limitations	N/A
Required if	N/A
Optional if	Always
Suggested Default	N/A

2.2.11 Other_Equipment

This section is for other equipment found at the facility that may have leaks from components such as valves, flanges, etc. One row is required for each facility. If any of the equipment counts are left blank, they will be treated as "0".

2.2.11.1 Facility_ID

Column A – See Facility_ID Section 2.2.2.1.

2.2.11.2 AGRU

This is the number of Acid Gas Removal Units at the facility. Examples include but are not limited to amine units and membrane units.

Column	B
Format	Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.11.3 Separators

This is the number of separators (including heater treaters) at the facility.

Column	C

Format	Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.11.4 Tanks

This is the number of tanks (including both oil/condensate and produced water) at the facility.

Column	D
Format	Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.11.5 Meter/Piping

This is the number of meters (including LACT units) at the facility.

Column	E
Format	Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.2.11.6 In-line Heaters

This is the number of in-line heaters (including fuel gas heaters) for both oil/condensate and produced water at the facility.

Column	F
Format	Number
Units	N/A
Limitations	N/A
Required if	Always
Optional if	N/A
Suggested Default	N/A

2.3 Advanced user inputs

This section includes instructions for generating custom user input files for leaks and compressors and custom decline curves.

2.3.1 User Specified Leaks Workbook

This section addresses User Specified – Leak Emission Data Source, see section 2.2.2.8. User Specified Leaks uses a separate excel workbook which is called by the Master_Equipment_List. Data used to populate these sheets should be taken from Leak Detection Surveys.

2.3.1.1 ListOfLeaks Sheet

This sheet is used to calculate the total number of leaks found during surveys. This is a running list indexing leaks found from surveys as they are found.

2.3.1.1.1 Leak Number

Column A - This is the indexed leak number as found by the leak detection surveys. This is a running list where a new entry is the next number in series.

2.3.1.1.2 Site_ID

Column B – This is the site where the leak was detected. This should match Facility_ID section 2.2.2.1

2.3.1.1.3 Measured Emission Rate

Column C – This is the measured emission rate from the survey. This value should be a number entered in units of Standard Cubic Feet per Hour (SCFH), and is a measurement of the whole gas. Individual constituent composition (i.e. Methane, etc.) will need to be determined.

2.3.1.1.4 Componenet Type

Column D – This sets the component type that the leak occurred from.

2.3.1.2 ListOfSites Sheet

This sheet is used to calculate the total number of components surveyed. Each time a leak is entered into the ListOfLeaks, ListOfSites should be updated as well.

2.3.1.2.1 Site_ID

Column A – This should match the Site_ID used in ListOfLeaks section 2.3.1.1.2.

2.3.1.2.2 Visit

Column B – This is the survey number for the site visit. Every time a site is surveyed, another visit number is added.

2.3.1.2.3 Calculation Option

Column C – This sets the method by which the component count will be calculated. There are three options to choose from which are discussed below.

(1) - This is the default method and requires the least amount of user input. The user will need to specify the “Region” (column D) of the U.S. (Eastern or Western) as well as the “Well Count” (column E). Choosing this option will select default values of 1 – wellhead, 1 – separator, and 1 – meter/piping will be

applied per wellhead. The remaining component counts by major equipment type will be taken from 40 CFR Part 98 Subpart W – table W-1B "*Default Average Component Counts for Major Onshore Natural Gas Production Equipment and Onshore Petroleum and Natural Gas Gathering and Boosting Equipment."*

(2) - This method allows the user to specify major equipment counts. The user will need to specify the "Region" (column D) of the U.S. (Eastern or Western) as well as the major equipment counts (columns F through K). The component counts will be taken from 40 CFR Part 98 Subpart W – table W-1B "*Default Average Component Counts for Major Onshore Natural Gas Production Equipment and Onshore Petroleum and Natural Gas Gathering and Boosting Equipment."*

(3) - This method requires the most user input.

2.3.1.2.4 Region
Column D – See Region section 3.2.2.4.

2.3.1.2.5 Well Count
Column E – This is the number of wells at the site.

2.3.1.2.6 Wellhead Count
Column F – This is the number of wellheads at the site.

2.3.1.2.7 Separator Count
Column G – This is the number of separators at the site.

2.3.1.2.8 Meters/Piping Count
Column H – This is the number of meter and associated piping at the site.

2.3.1.2.9 Compressor Count
Column I – This is the number of compressors at the site.

2.3.1.2.10 In-line Heater Count
Column J – This is the number of inline heaters at the site.

2.3.1.2.11 Dehydrator Count
Column K – This is the number of dehydrators at the site.

2.3.1.2.12 Valves
Column L – This is the number valves at the site.

2.3.1.2.13 Connectors
Column M – This is the number of connectors at the site.

2.3.1.2.14 Open-ended Lines
Column N – This is the number of open-ended lines at the site.

2.3.1.2.15 Pressure Relief Valve
Column O – This is the number of pressure relief valves at the site.

2.3.1.2.16 Other

Column P – This is the number of other type components that don't fall into any of the above categories at the site.

2.3.2 Compressor Data Workbook

This section addresses User Specified Compressor data if specified in the input sheet (See section 2.2.9.5). Data used to populate these sheets should be taken from facility data.

2.3.2.1 Driver Type Sheet

This sheet is where the user will input the quantity of each type of compressor driver for each type of compressor at the facility.

2.3.2.1.1 Driver Type

Column A – This is the different types of compressor drivers. See section 3.2.9.7.

2.3.2.1.2 Centrifugal Compressor

Column B – This is the number of centrifugal compressors for each type of driver.

2.3.2.1.3 Reciprocating Compressor

Column C – This is the number of reciprocating compressors.

2.3.2.2 Driver Size

This sheet is used to match the number of driver types with their respective power output. This is the manufacturer's maximum rated horsepower.

2.3.2.2.1 Compressor Rated Horsepower

Column A – This is the manufacturer's maximum rated brake horsepower (bhp) of the driver. The list of horsepower is incremented by 50 horsepower. If the manufacturer's maximum rated horsepower falls between two increments round as appropriate (e.g. a 74 hp unit would be rounded to 50 hp and a 75 hp unit would be rounded to 100 hp). A horsepower higher than what is in the current sheet (the example sheet maximum is 37,950 hp) may be added as additional rows as needed.

2.3.2.2.2 Electric Motor

Column B – This is the number of electric motors of the horsepower listed in Column A used to drive compressors at the facility. See section 3.2.9.7 for driver information.

2.3.2.2.3 2SLB

Column B – This is the number of two-stroke lean-burn RICEs of the horsepower listed in Column A used to drive compressors at the facility. See section 3.2.9.7 for driver information.

2.3.2.2.4 4SLB

Column B – This is the number of four-stroke lean-burn RICEs of the horsepower listed in Column A used to drive compressors at the facility. See section 3.2.9.7 for driver information.

2.3.2.2.5 4SRB

Column B – This is the number of four-stroke rich-burn RICEs of the horsepower listed in Column A used to drive compressors at the facility. See section 3.2.9.7 for driver information.

2.3.2.2.6 Turbine

Column B – This is the number of gas turbines of the horsepower listed in Column A used to drive compressors at the facility. See section 3.2.9.7 for driver information.

2.3.2.3 OPtime Sheet

This sheet is a distribution of the amount of time the compressor spends operating, not operating but pressurized and not operating depressurized each year. Note that the numbers in each row must add up to 8,760 hours

2.3.2.3.1 OPtime

The number of hours the compressor operates per year

2.3.2.3.2 NOPtime

The number of hours the compressor is not operating but pressurized per year

2.3.2.3.3 NODtime

The number of hours the compressor is not operating and not pressurized per year

2.3.2.4 Cylinder Count Sheet

This sheet matches the number of cylinders a reciprocating natural gas compressor has with the driver rated horsepower. This sheet is **not** the number of combustion cylinders a RICE driver has.

2.3.2.4.1 Cylinder Count

Column A – This is a list of the number of cylinders a compressor may have. Additional amounts may be added

2.3.2.4.2 1000

Column B – This is the number of compressors with a driver less than or equal to 1,000 bhp broken down by compressor cylinder count.

2.3.2.4.3 1500

Column C – This is the number of compressors with a driver greater than 1,000 bhp but less than or equal to 1,500 bhp broken down by compressor cylinder count.

2.3.2.4.4 2000

Column D – This is the number of compressors with a driver greater than 1,500 bhp but less than or equal to 2,000 bhp broken down by compressor cylinder count.

2.3.2.4.5 Max

Column E – This is the number of compressors with a driver greater than 2,000 bhp broken down by compressor cylinder count.

2.3.2.4.6 Example Input

For example, if the following configuration wanted to be modeled:

- Three 630 hp engines each driving a 3 cylinder compressor;
- One 500 hp engine driving a 4 cylinder compressor;
- One 1,100 hp engine driving a 6 cylinder compressor;
- Five 1,400 hp engines each driving a 12 cylinder compressor;
- Six 1,560 hp engines each driving a 6 cylinder compressor;
- One 1,900 hp engine driving a 16 cylinder compressor;
- Two 3,000 hp engines each driving a 12 cylinder compressor; and
- One 4,000 hp engine driving a 16 cylinder compressor.

This would be entered into the sheet as follows:

2.3.2.5 Fuel Consumption Sheet

This sheet matches the bhp-specific fuel consumption (BSFC) in units of (Btu/bhp-hr) of a RICE and turbines with its manufacturer's maximum rated horsepower. Electric drivers are not included.

2.3.2.5.1 Fuel Consumption

Column A - This is the list of fuel consumption values in Btu/bhp-hr to be matched to the engines. additional values may be added as needed to the bottom of the sheet.

2.3.2.5.2 2SLB

Column B - This is the number of 2SLB engines at each fuel consumption level.

2.3.2.5.3 4SLB

Column C - This is the number of 4SLB engines at each fuel consumption level.

2.3.2.5.4 4SRB

Column D - This is the number of 4SRB engines at each fuel consumption level.

2.3.2.5.5 Turbine

Column E - This is the number of gas turbine engines at each fuel consumption level.

2.3.2.5.6 Example Input

For example, if the following configuration wanted to be modeled:

- Two 2SLB and one 4SRB with a BSFC of 6,820 Btu/hp-hr;
- Three 4SLB and four 4SRB with a BSFC of 6,550 Btu/hp-hr;
- Six 2SLB, two 4SLB, and five 4SRB, with a BSFC of 6,770 Btu/hp-hr; and
- One turbine with a BSFC of 6,590 Btu/hp-hr

This would be entered into the sheet as follows:

Note that rows are highlighted only to show where non-zero values are entered. Highlighting rows is not required to run the model.

2.3.2.6 Seals Sheet

This is the count of dry and wet used on centrifugal compressors at the facility. Seal Type

Column A – This is the type of seal, wet or dry specified in the sheet as "wetSeal" and "drySeal".

2.3.2.6.1 Counts

Column B – This is the total quantity of the individual seal types.

2.3.2.6.2 Example Input

For example, if the following configuration wanted to be modeled:

- One wet seal compressor; and
- Five dry seal compressors.

This would be entered into the sheet as follows:

2.3.3 Generating Custom Decline Curves

Decline curves are used to determine the amount of fluid a well produces during a specific point in time. The MEET model uses the equation to predict decline:

$$Q_t = \frac{Q_i}{(1 + b * D_i * t)^{\frac{1}{b}}}$$

Where:

Q_t	=	Production rate in month t, bbl/day
Q_i	=	Production Rate at time 0, bbl/day
b	=	Hyperbolic parameter (degree of curvature of the line), dimensionless
D_i	=	Initial decline rate, 1/month
t	=	month of production

The model uses the same b and D_i factors for all fluids (i.e. gas, oil and water). The initial production rate at time 0, Q_i, is specified for each fluid. Below is one technique to determine the best Qi, b and Di for actual production data using excel and the sum of least squares method.

Step 1: Set up an excel sheet as follows. The number of months should correspond to the number of months of data the user has.

Step 2: Enter Production Data into column B and add months to column A as needed

Step 3: Enter decline equation into column C and copy the equation down the row. The equation is based on the variables in Cells B2-B4 and the month in column A. The equation in cell C7 would be:

=$B$2/(1+$B$3*$B$4*A7)^(1/$B$3)

Step 4: Enter and equation to calculate the square of the difference between the decline equation and actual production data and copy the equation down the row. Here is what the equation in cell D7 would be:

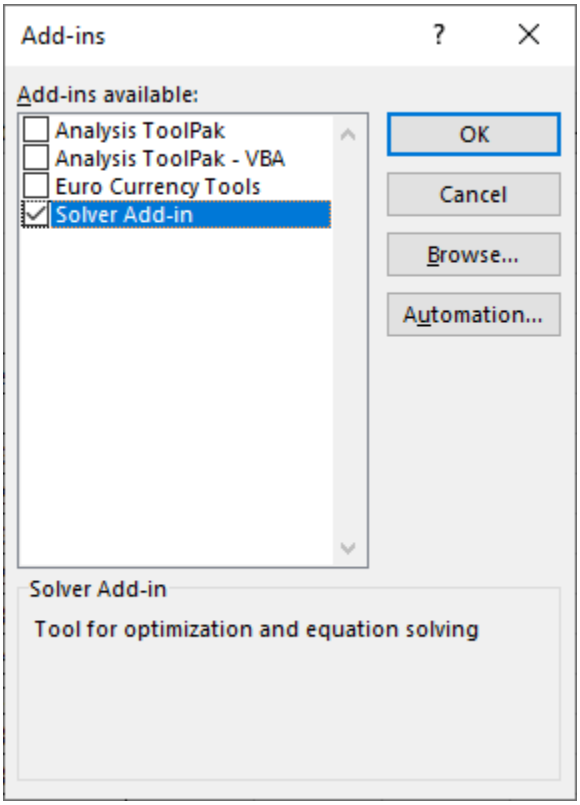
=(B7-C7)^2

Step 5: Sum the values in column D below the last data point.

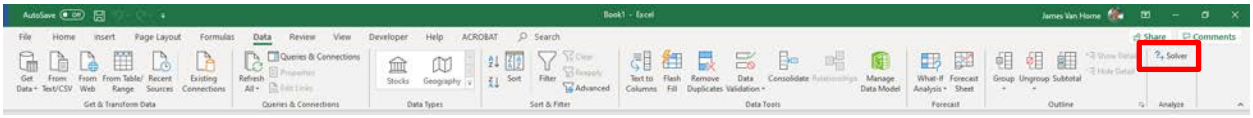
Step 6: Enter guesses for Q_i, b, and Di in Cells B2-B4. A good starting point for Q_i is the production in month 0 (i.e. the value in B7). b and D_i are typically less than 1.

Step 7: Activate the solver add in. It can be found under Developer>Add-ins>Excel Add-ins in the ribbon.

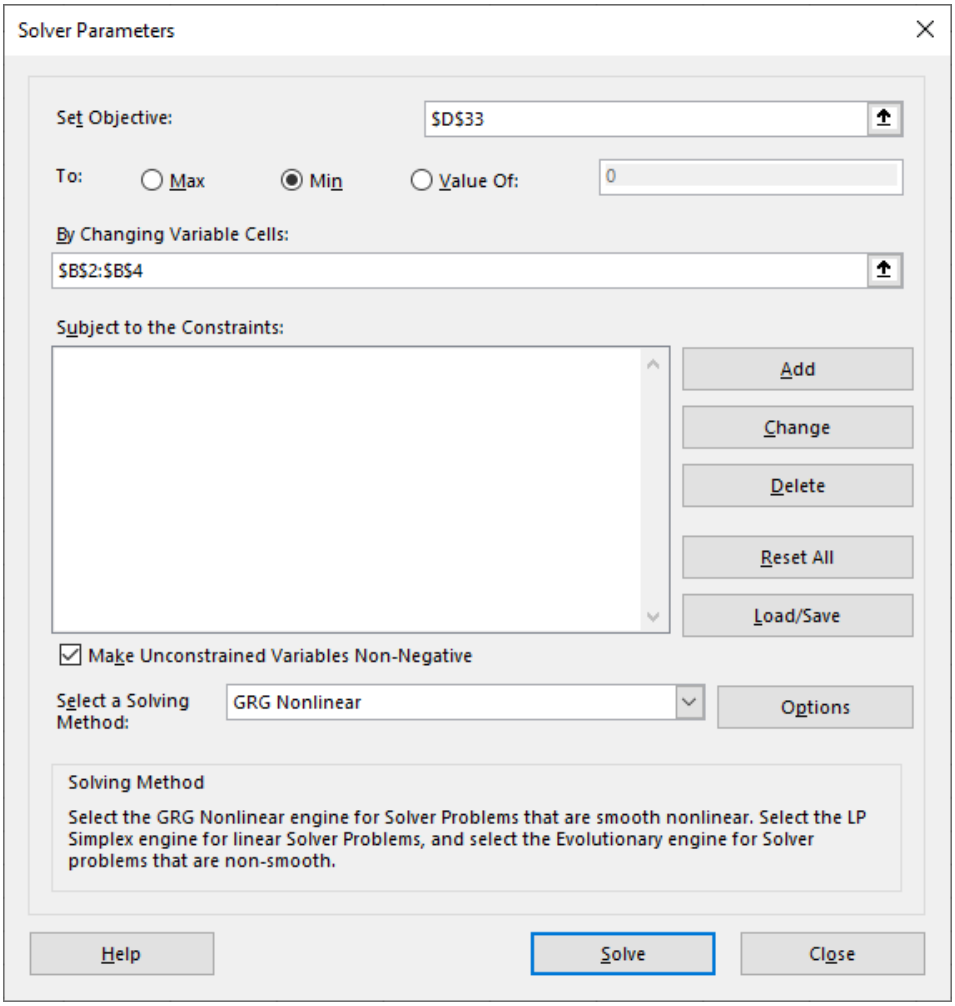
Check the box next to the Solver Add-in to activate it and press OK.



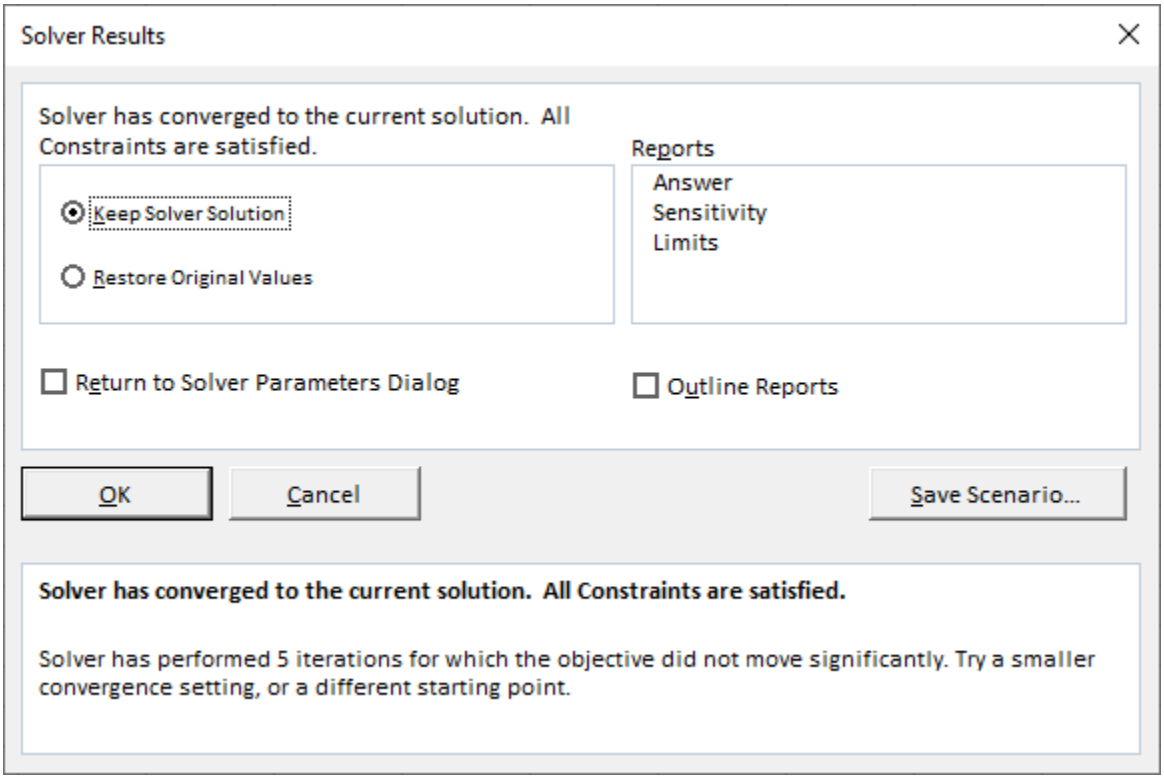
Step 8: Solve Q_i, b and D_i. Click on the solver under Data>Analyze>Solver



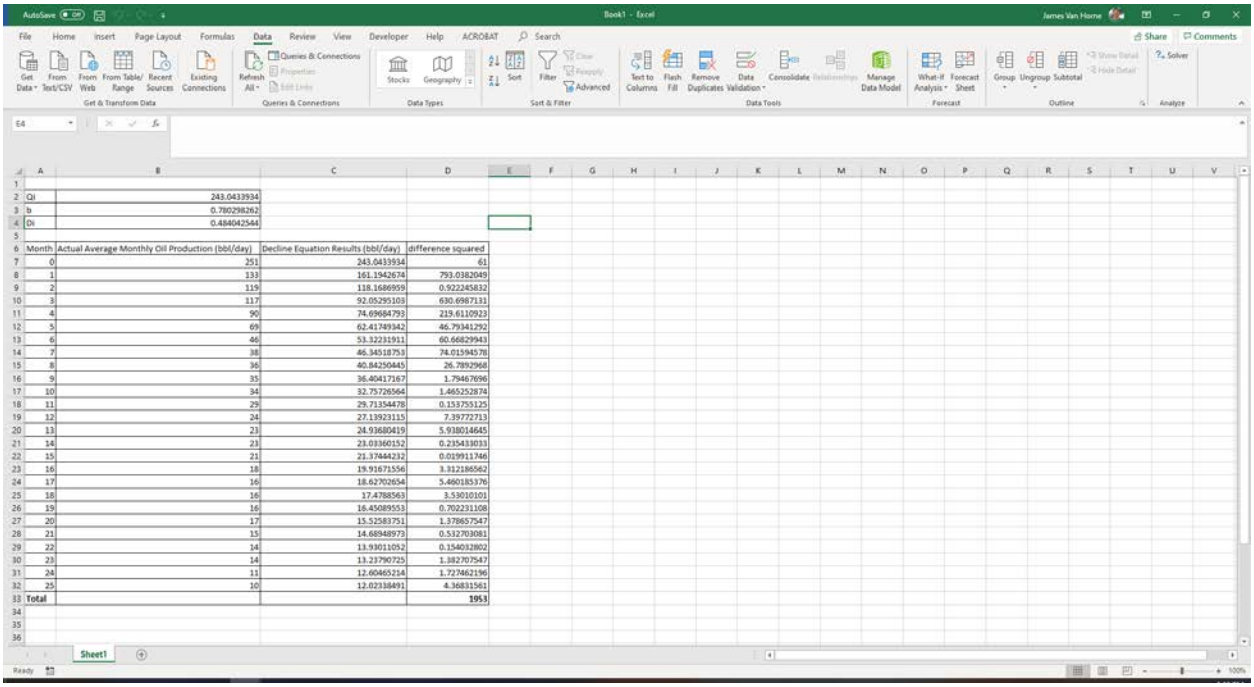
Set your objective to the cell that sums all the values in column D (i.e. the last cell with data in column D). Set the "To:" to "min" to minimize the value you set as your objective. Change your "By Changing Variable Cells:" to the cells with the Q_i, b, and D_i guesses (i.e. Cells B2-B4). And click solve.



When the results pop up chose “keep Solver solution” and press OK

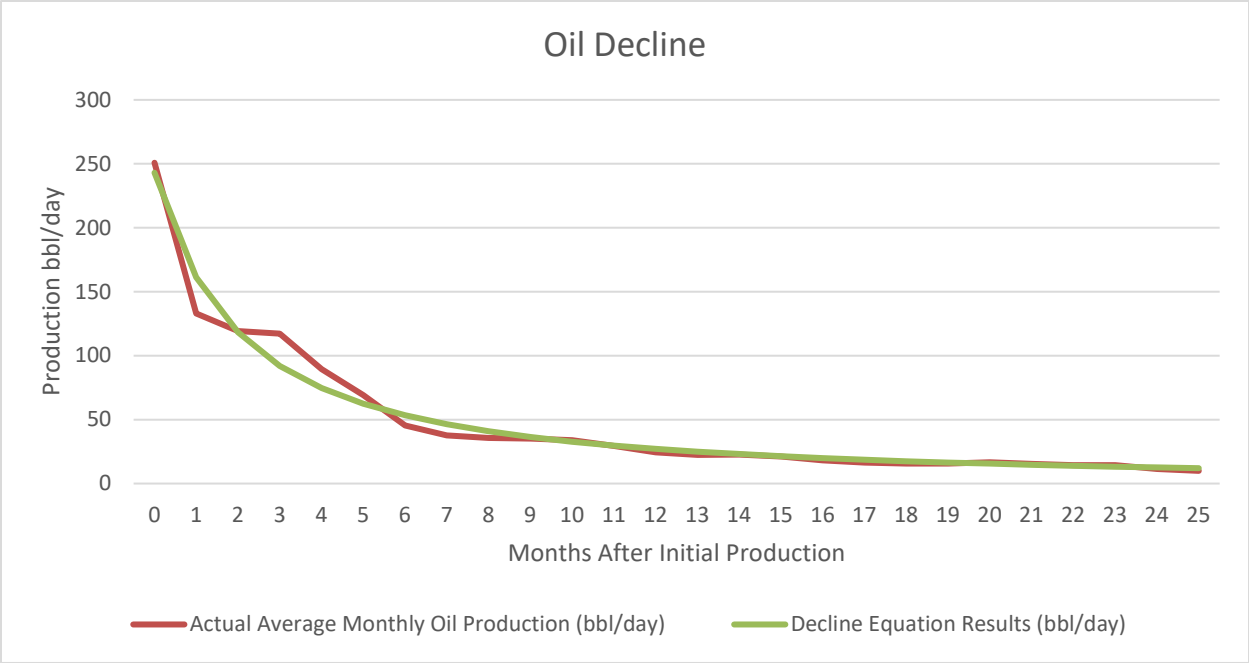


The values in cells B2-B4 are the best fit for the data and can be used in the MEET model.



	A	B	C	D
2	Qi	243.0433934		
3	b	0.780298262		
4	Di	0.484042544		
6	Month	Actual Average Monthly Oil Production (bbl/day)	Decline Equation Results (bbl/day)	difference squared
7	0	251	243.0433934	61
8	1	133	161.1942674	793.0382049
9	2	119	118.1686959	0.922245832
10	3	117	92.05295103	630.6987131
11	4	90	74.69684793	219.6110923
12	5	69	62.41749342	46.79341292
13	6	46	53.32231911	60.66829943
14	7	38	46.34518753	74.01594578
15	8	36	40.84250445	26.7892968
16	9	35	36.40417167	1.79467696
17	10	34	32.75726564	1.465252874
18	11	29	29.71354478	0.153755125
19	12	24	27.13923115	7.39772713
20	13	23	24.93680419	5.938014645
21	14	23	23.03360152	0.235433033
22	15	21	21.37444232	0.019911746
23	16	18	19.91671556	3.312186562
24	17	16	18.62702654	5.460185376
25	18	16	17.4788563	3.53010101
26	19	16	16.45089553	0.702231108
27	20	17	15.52583751	1.378657547
28	21	13	14.68948973	0.532703081
29	22	14	13.93011052	0.154012802
30	23	14	13.23790725	1.382707547
31	24	11	12.60465214	1.727462196
32	25	10	12.02338491	4.36831561
33	Total			1953

The factors can be checked by graphing columns B and C.



3 Running the MEET model

MEET is a python-based program. Procedures for running the MEET model are constantly evolving. Users should visit the MEET webpage to find the current version of the instructions to run the model.

MEET webpage: http://dept.ceer.utexas.edu/ceer/meet

3.1 Drilldown operation

The Drilldown feature allows the user to revisit a portion of a previously completed simulation using a different time granularity. For example, one specific day can be viewed in detail from a previously run simulation that was one year in duration. Users should visit the MEET webpage to find the current version of the instructions for the drilldown feature.

4 Outputs

4.1 Output File Summary

Output files are located in the file directory specified in the input with a timestamp added. Under the file is a subfolder for each Monte Carlo iteration. Within each subfolder are a number of output files for that iteration. The emissions are presented in kg per model duration. They do not account for any mitigation such as control or capture of emissions. The easiest way to navigate these is to sort by file type. The four types are: .html, .json, .log, and .csv. A summary of the .html, .log, and .csv files is described below.

4.1.1 Naming Convention

Each output file labels equipment using the same naming convention that is detailed below. The general convention is "EquipmentType_FacilityID_WellID_EquipmentID"

Where:

EquipmentType is the type of equipment such as compressor, cip (chemical injection pump), condensate tank, pneumatics, unloading (etc.

FacilityID is the ID of the facility the equipment is located at as entered in the Facility_Lists sheet of the input workbook

WellID is the ID of the well the equipment is associated with as entered in the Wells sheet of the input workbook. If the equipment is not associated with a well this is omitted from the name.

EquipmentID is the ID of the equipment as entered in the Wellpad_TankFlash, Wellpad_Pneumatics, Wellpad_ChemicalInjectionPump, compressors and dehydrators sheets of the input workbook.

A few examples are provided below:

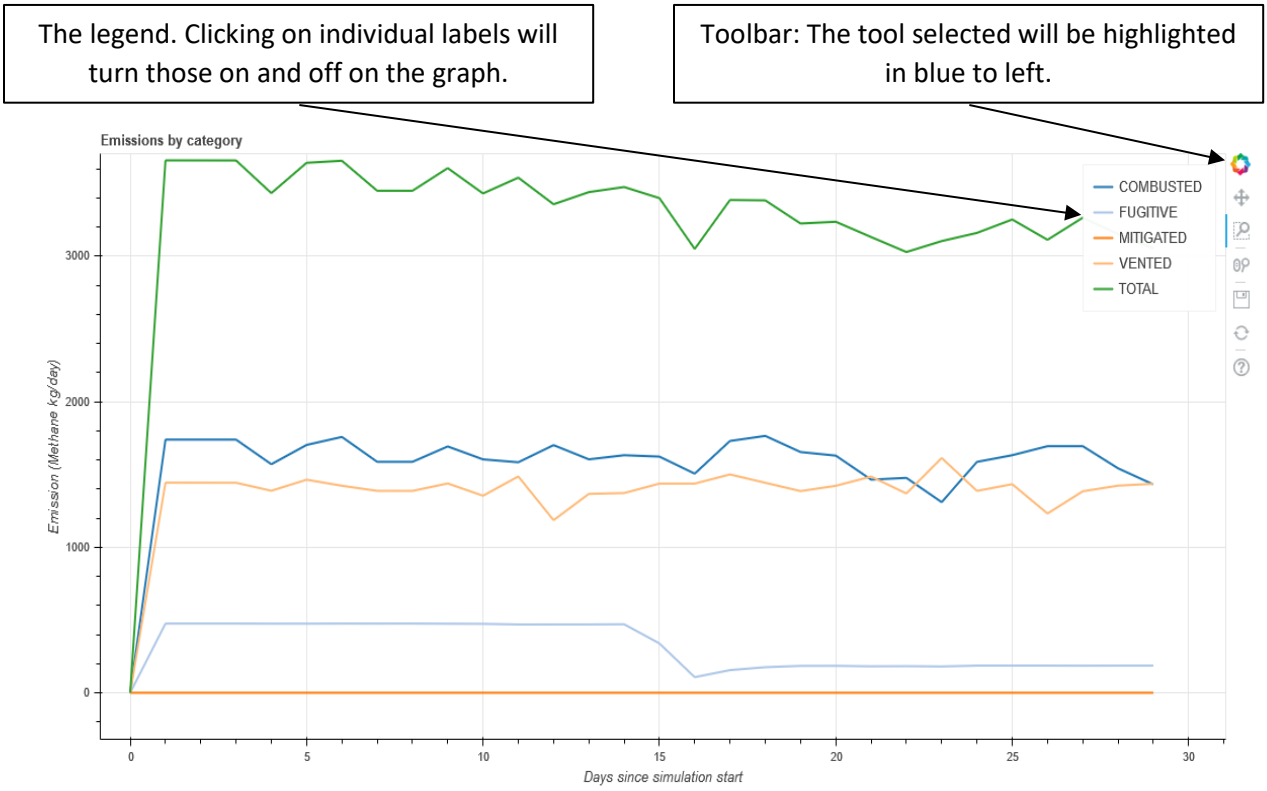
"cip_Example Well Pad_1234HZ_Pump 1"

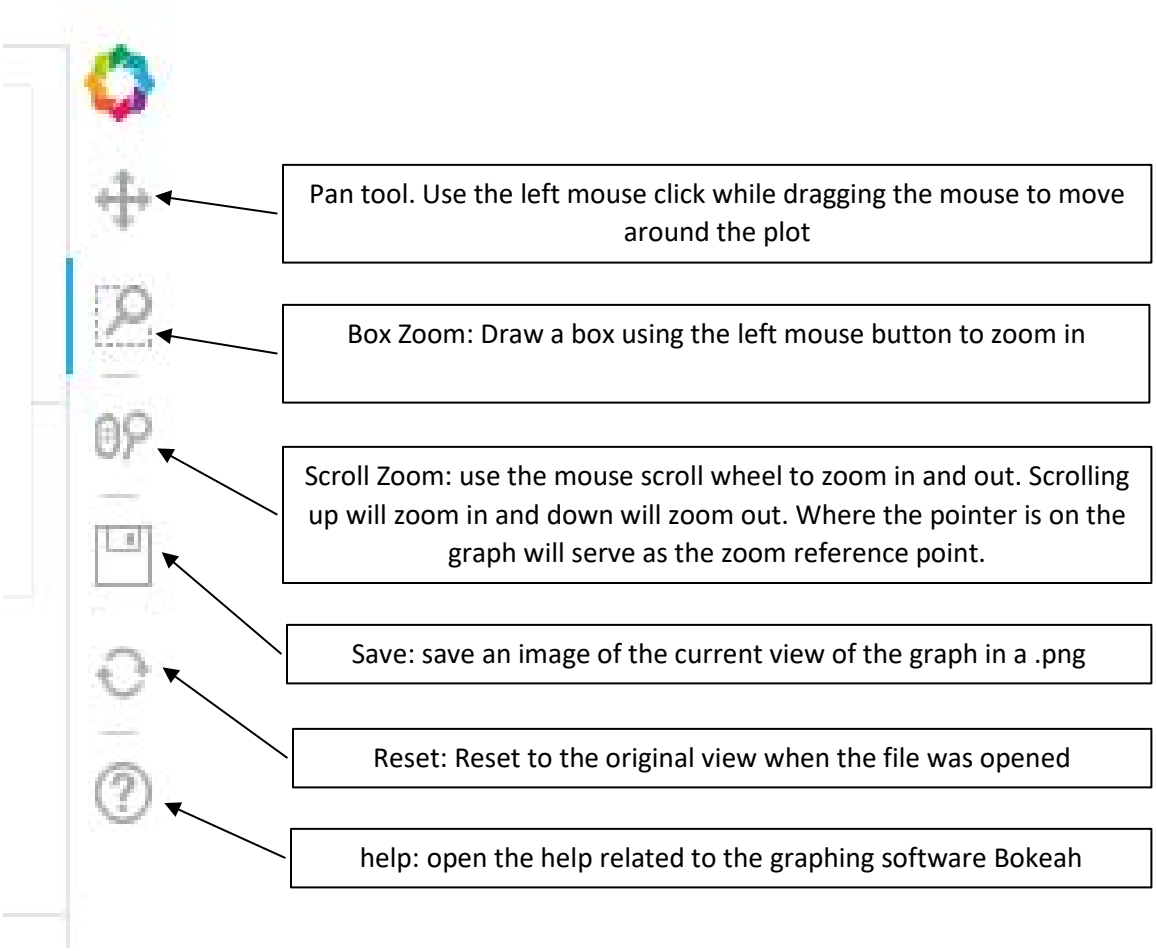
"compressor_2_1"

"dehydrator_5_9"

4.1.2 HTML files

These files are automatically generated graphs that are viewable using a web browser (Edge, Firefox, Chrome, etc.). These graphs show the mass emission rate of methane over time by site, equipment, and emission category. Graphs are automatically suppressed for very large sites (> 50 emitters). Plots for larger sites can be generated using the TimeSeries.csv file detailed in section 4.1.3.5. Depending on the size of the sites in your simulation, you may not see graphs for every site. The figure below has useful information on how best to use these files. A summary of each html file is described below.





4.1.2.1 equipmentTypeGraph.html

A graph of emission rates by equipment type and total emissions from all equipment. Equipment is divided into the following types:

ChemicalInjectionPump: Chemical injection pumps specified in the Wellpad_ChemicalInjectionPump and Wells sheets of the input workbook

Compressor: Compressor driver combustion emissions, starter vent, and blowdown emissions specified in the Compressors sheet of the input workbook

CompressorLeak: Compressor seal vent and rod packing emissions specified in the Compressors sheet of the input workbook.

Dehydrator: Glycol dehydrator still vent and flash tank emissions (if equipped) specified in the Dehyrators sheet of the input workbook.

Leak: Emissions from leaks from valves, connectors, flanges, and other components specified in the Facility_List and Other_Equipment sheets of the input workbook.

Pneumatic: Emissions from pneumatic controllers and pumps (other than chemical injection pumps) specified in the Facility_List, Wells, and Wellpad_Pneumatics sheets of the input workbook.

TankFlash: Emissions due to flashing in the condensate, oil and produced water tanks specified in the Wells, and Wellpad_TankFlash sheets of the input workbook.

Unloading: Well liquids unloading event emissions specified in the Wells and Wellpad_UnloadingTiming sheets of the input workbook.

Well: Well completion emissions specified in the Wells sheet of the input workbook.

4.1.2.2 Site[ ]_equipment.html

A graph of emissions at a facility by source. Each facility will have its own file.

4.1.3 CSV files

These files are comma separated variable (CSV) data files that are able to be opened by a program such as Microsoft Excel. However, Excel may have a difficult time processing very large csv files such as the TimeSeries.csv and gas_composition.csv files. Simulations which have a long simulation duration, a smaller plot time interval, and or a large number of emitters will result in very large TimeSeries.csv and gas_composition.csv files. If this occurs, users may re-run the simulation with a larger plot time interval (such as DAYS, MONTHS, or YEARS). To observe a specific portion of the simulation results at a finer temporal resolution use the drill-down functionality described in Section 3.1. . Pivot charts and pivot tables in Excel are good ways to filter and create charts from the data.

4.1.3.1 equipmentSummary.csv

A summary of total methane emissions in kg for the modeling period by individual equipment and Category (combusted, fugitive, mitigated, vented). The current version of the model does not use the mitigated category.

4.1.3.2 gas_composition.csv

Emissions over time by equipment, category (combusted, vented, fugitive, mitigate) and species (i.e. methane, ethane, propane, etc.). Due to the number of data points, especially for large numbers of emitters, this file is best viewed using pivot tables.

4.1.3.3 siteSummary.csv

A summary of sites included in the model. The file includes a summary of some of the input parameters by site. Emissions by category (combusted, fugitive, etc.) and the total emissions over the model duration in kilograms by site is presented.

4.1.3.4 snaps.csv

A file indicating the operating status of various pieces of equipment. For example, this field will indicate if the well is in preproduction, producing, unloading liquids, shut in or venting. The resolution of the data is based on the plot interval in the Global_Simulation_Parameter sheet of the input sheet. Due to the number of data points, especially for large numbers of emitters, this file is best viewed using pivot tables.

4.1.3.5 TimeSeries.csv

A file of time stamped activity and emission factors. Factors include things such as vent rates in scf or bbl per dump event. Due to the number of data points, especially for large numbers of emitters, this file is best viewed using pivot tables.

4.1.4 Events.log

This file is a timestamped record of all events that occurred in the simulation. The event log primarily documents two types of events: create device events, and state transition events. All emitters in the simulation will have a "CREATE-DEVICE" entry at time t=0. Emitters can neither be created nor destroyed while the simulation is running. Each time an emitter changes its operating conditions, it will log a "STATE_TRANSITION" event. Each state transition will have a START event and a STOP event. State transitions are instantaneous, so the STOP event of a prior event will have the same timestamp as the START event of the subsequent state.

4.2 Additional Post Processing

The model provides various iterations of what emissions could possibly be. All of the data from these iterations may need to be averaged and/or plotted together to determine the most likely scenario of emissions. Additionally, pivot tables are useful in sorting and viewing certain csv files.

Additionally, the emissions are presented as unmitigated and a control efficiency may need to be applied to certain sources. For example, a storage tank where vapors are sent to a flare would need to have the emissions multiplied by the flare methane destruction efficiency, a typical default value is 98 percent. Another example is a gas processing plant that uses an instrument air system for pneumatic devices would need to apply a 100 percent control efficiency to pneumatic controllers since the controllers release air instead of natural gas when they actuate.

5 Sources

D. Allen et al. “A Methane Emission Estimation Tool (MEET) for predictions of emissions from upstream oil and gas sources with fine scale temporal and spatial resolution. Part 1: Well sites”

D. Zimmerle et al., “Appendix A Methane Emissions from Gathering Compressor Stations in the U.S.:,” p. 549.

D. Zimmerle et al., “Characterization of Methane Emissions from Gathering Compressor Stations: Final Report,” Final Report, p. 62.

B. Luck et al., “Methane Emissions from Gathering and Boosting Compressor Stations in the U.S.,” p. 120.

T. Vaughn et al., “Methane Emissions from Gathering and Boosting Compressor Stations in the U.S.,” p. 23.

D. Zimmerle et al., “Methane Emissions from Gathering and Boosting Compressor Stations in the U.S.:,” p. 63.

D. Zimmerle et al., “Methane Emissions from Gathering Compressor Stations in the U.S.,” p. 27.

D. J. Zimmerle et al., “Methane Emissions from the Natural Gas Transmission and Storage System in the United States,” Environmental Science, p. 10.

D. J. Zimmerle et al., “Methane Emissions from the Natural Gas Transmission and Storage System in the United States,” Environ. Sci. Technol., vol. 49, no. 15, pp. 9374–9383, Aug. 2015, doi: 10.1021/acs.est.5b01669.

D. Zavala-Araiza et al., “Super-emitters in natural gas infrastructure are caused by abnormal process conditions,” Nat Commun, vol. 8, no. 1, p. 14012, Apr. 2017, doi: 10.1038/ncomms14012.

F. Cardoso-Saldaña et al. “A Methane Emission Estimation Tool (MEET) for predictions of emissions from upstream oil and gas sources with fine scale temporal and spatial resolution. Part 3: Emission composition”

T. L. Vaughn et al., “Temporal Variability Largely Explains Difference in Top-down and Bottom-up Estimates of Methane Emissions from a Nat- ural Gas Production Region,” p. 37.

T. L. Vaughn et al., “Temporal variability largely explains top-down/bottom-up difference in methane emission estimates from a natural gas production region,” p. 6.

U.S. Energy Information Administration, “Oil and Gas Supply Module of the National Energy Modeling System: Model Documentation 2017”, Feb. 2017

Appendix A: Designation of Eastern vs. Western U.S.[3]

Eastern U.S.	Western U.S
Connecticut	Alabama
Delaware	Alaska
Florida	Arizona
Georgia	Arkansas
Illinois	California
Indiana	Colorado
Kentucky	Hawaii
Maine	Idaho
Maryland	Iowa
Massachusetts	Kansas
Michigan	Louisiana
New Hampshire	Minnesota
New Jersey	Mississippi
New York	Missouri
North Carolina	Montana
Ohio	Nebraska
Pennsylvania	Nevada
Rhode Island	New Mexico
South Carolina	North Dakota
Tennessee	Oklahoma
Vermont	Oregon
Virginia	South Dakota
West Virginia	Texas
Wisconsin	Utah
	Washington
	Wyoming

[3] 40 CFR Part 98 Table W-1D

Appendix B: Select List of Oil and Gas Regulators

State	Regulator
Alaska	Alaska Oil and Gas Conservation Commission
Arkansas	Arkansas Oil and Gas Conservation Commission
California	California Department of Conservation
Colorado	Colorado Oil and Gas Conservation Commission
Kansas	Kansas Corporation Commission
Louisiana	Louisiana Department of Natural Resources
Montana	Montana Board of Oil & Gas Conservation
New Mexico	New Mexico Oil Conversation Division
North Dakota	North Dakota Oil and Gas Division
Ohio	Ohio Department of Natural Resources
Oklahoma	Oklahoma Corporation Commission
Pennsylvania	Pennsylvania Department of Environmental Protection
Texas	Texas Railroad Commission
Utah	Utah Division of Oil, Gas and Mining
West Virginia	West Virginia Department of Environmental Protection
Wyoming	Wyoming Oil & Gas Conservation Commission

Appendix C: EIA NEMS Shale Plays Data[4]

The Bakken Oil Play is in eastern Montana and Western North Dakota near the city of Williston, ND. It includes the following counties:

- Richland, MT
- Roosevelt, MT
- Sheridan, MT
- Billings, ND
- Burke, ND
- Divide, ND
- Dunn, ND
- Golden Valley, ND
- Mckenzie, ND
- Mclean, ND
- Mercer, ND
- Mountrail, ND
- Stark, ND
- Williams, ND

The Barnett Gas Play is in north central Texas near the cities of Dallas and Fort Worth. It includes the following counties:

- Clay, TX
- Cooke, TX
- Dallas, TX
- Denton, TX
- Ellis, TX
- Erath, TX
- Hill, TX
- Hood, TX
- Jack, TX
- Johnson, TX
- Montague, TX
- Parker, TX
- Shackelford, TX
- Somervell, TX
- Stephens, TX
- Tarrant, TX
- Wise, TX

Eagle Ford Gas Play is in south central Texas near the cities of Laredo and Corpus Christi. It includes the following counties:

- Atascosa, TX
- Bee, TX
- DeWitt, TX
- Dimmit, TX
- Karnes, TX
- LaSalle, TX
- Lavaca, TX
- Live Oak, TX
- McMullen, TX
- Webb, TX
- Zavala, TX

Fayetteville Gas Play is in central Arkansas just north of Little Rock. It includes the following counties:

- Cleburne, AR
- Conway, AR
- Faulkner, AR
- Independence, AR
- Jackson, AR
- Van Buren, AR
- White, AR

The Haynesville-Bossier Gas Play is in central eastern Texas and north western Louisiana near the city of Shreveport, LA. It includes the following counties and perishes:

- Bienville, LA
- Bossier, LA
- Caddo, LA
- Claiborne, LA
- De Soto, LA
- Red River, LA
- Sabine, LA
- Webster, LA
- Harrison, TX
- Nacogdoches, TX
- Panola, TX
- Rusk, TX
- Sabine, TX
- San Augustine, TX
- Shelby, TX

[4]U.S. Energy Information Administration, “Oil and Gas Supply Module of the National Energy Modeling System: Model Documentation 2017”, Feb. 2017

The Marcellus Gas Play is in Northern and western West Virginia and Central Pennsylvania. It includes the following counties:

- Allegheny, PA
- Armstrong, PA
- Bradford, PA
- Butler, PA
- Cameron, PA
- Centre, PA
- Clarion, PA
- Clearfield, PA
- Clinton, PA
- Elk, PA
- Fayette, PA
- Greene, PA
- Indiana, PA
- Jefferson, PA
- Lycoming, PA
- McKean, PA
- Potter, PA
- Somerset, PA
- Sullivan, PA
- Susquehanna, PA
- Tioga, PA
- Washington, PA
- Westmoreland, PA
- Wyoming, PA
- Barbour, WV
- Boone, WV
- Brooke, WV
- Doddridge, WV
- Gilmer, WV
- Harrison, WV
- Jackson, WV
- Kanawha, WV
- Lincoln, WV
- Logan, WV
- Marion, WV
- Marshall, WV
- McDowell, WV
- Ohio, WV
- Preston, WV
- Putnam, WV
- Ritchie, WV
- Roane, WV
- Taylor, WV
- Tyler, WV
- Upshur, WV
- Wetzel, WV
- Wyoming, WV

Spraberry Oil Play is in western Texas near the city of Midland, TX. It includes the following counties:

- Andrews, TX
- Borden, TX
- Crane, TX
- Dawson, TX
- Ector, TX
- Gaines, TX
- Glasscock, TX
- Howard, TX
- Irion, TX
- Lynn, TX
- Martin, TX
- Midland, TX
- Pecos, TX
- Reagan, TX
- Reeves, TX
- Sterling, TX
- Upton, TX

Utica Gas Play is in eastern Ohio and western Pennsylvania near the city of Youngstown, OH. It includes the following counties:

- Belmont, OH
- Carroll, OH
- Columbiana, OH
- Guernsey, OH
- Harrison, OH
- Monroe, OH
- Noble, OH
- Beaver, PA
- Lawrence, PA

Wolfcamp Oil Play is in western Texas and southwestern New Mexico near the city of midland. It includes the following counties:

- Chaves, NM
- Eddy, NM
- Lea, NM
- Andrews, TX
- Crane, TX
- Crockett, TX
- Culberson, TX
- Gaines, TX
- Glasscock, TX
- Hockley, TX
- Howard, TX
- Irion, TX
- Loving, TX
- Mitchell, TX
- Pecos, TX
- Reagan, TX
- Reeves, TX
- Schleicher, TX
- Scurry, TX
- Sterling, TX
- Upton, TX
- Ward, TX
- Winkler, TX
- Yoakum, TX

Woodford Oil Play is in central Oklahoma near Oklahoma City. It includes the following counties:

- Blane, OK
- Canadian, OK
- Dewey, OK
- Kingfisher, OK
- Mcclain, OK

Production Characteristics for Shale Oil Plays[5]

Play name	Initial (30-day average) Oil production rate (bbl/day)			Total Production for the life of the well (Mbbl/well)		
	Average	Max	Min	Average	Max	Min
Bakken	536	1589	68	181	346	13
Spraberry	306	862	22	88	449	11
Wolf Camp	252	843	26	72	219	11
Woodford	303	608	27	78	168	23

Production Characteristics for Shale Gas Plays[5]

Play name	Initial (30 day average) Gas production rate (Mscf/day)			Total Production for the life of the well (MMscf/well)		
	Average	Max	Min	Average	Max	Min
Barnett	1,373	3,444	110	985	2,405	21
Eagle Ford	3,483	11,492	312	1,059	2,442	87
Fayetteville	2,083	2,605	847	1,778	2,306	935
Haynesville-Bossier	14,485	24,935	871	3,338	6,273	554
Marcellus	6,399	29,762	23	2,687	7,643	32
Utica	6,722	13,253	2,301	3,166	6,754	1,426

[5] Summarized data from U.S. Energy Information Administration, "Oil and Gas Supply Module of the National Energy Modeling System: Model Documentation 2017", Feb. 2017