NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Natural Gas Extraction Produced Water Tank Venting

Reference Flow: 1 kg of Natural Gas Produced

Brief Description: This unit process quantifies the amount of gas vented and flared during natural gas production from produced water tanks through flash losses and tank working and breathing losses.

Section I: Meta Data

Geographical Coverage: U.S. **Region:** U.S.

Year Data Best Represents: 2011

Process Type: Extraction Process (EP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Captured

Flows Aggregated in Data Set:

☒ Process ☐ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☒ Greenhouse Gases	☒ Criteria Air Pollutants	☐ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

MCF_Prod

[MCF/Well] Volume of natural gas produced per well

PW_Prod

[bbl/Well] Volume of water produced per well

Tank_Frac

[dimensionless] Fraction of produced water sent to tanks

EF_CH4

[lbm/bbl] Methane emission rate from produce water tanks per volume water throughput

WF_CH4

[kg/kg] Mass fraction of methane in emission stream

MW_Gas

[kg/kgmol] Molecular weight of non-associated gas

Tracked Input Flows:

Tracked Output Flows:

Natural Gas [intermediate flow]

[Reference Flow] Natural gas produced

NG_VandF

[Intermediate flow] Non-associated gas vented and flared from condensate tank

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_NG_Extraction_ProducedWaterTank_Venting_2014.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with natural gas well produced water tank filling and storage. Accounted for are the gaseous losses from flashing during the filling of tanks and breathing/working losses from water storage. Default parameter values presented are regional averages and values are available for conventional natural gas wells and Coal

Bed Methane (CBM) production. **Figure 1** shows the 11 onshore regions. The reference flow of this unit process is: 1 kg of natural gas produced.

Boundary and Description

A common bi-product of natural gas is produced water, which is a brine solution that condenses out of the gas or is cleared of the well during liquid unloading. A separator at the extraction site will separate the produced water from the gas and pipe it to a produced water storage tank. Often, produced water tanks are at atmospheric pressure and vented directly to the atmosphere. Emission types from produced water tanks include flashing, working and breathing losses. Flashing losses are those due to the volatilization of the lightest end liquids as the produced water enters the atmospheric tank from the slightly more pressurized separator. Working losses occur as the tank is filled and make up the volume of residual gas in the tank as it is displaced by liquid produced water. Breathing losses are due to the slow volatilization of the produced water while it is stored in the tank which is a function of the daily temperature fluctuation of the region in which the water is produced.

This unit process utilizes the Environmental Protection Agency's (EPA) Oil and Gas Emission Estimation Tool (O&G Tool). This tool exists as a Microsoft Access database containing county level data on natural gas production, well counts, device counts, and various device characteristics. The O&G Tool was developed by compiling data from 49 sources including state and basin level sampling studies, federal reports and expert approximations. Where better data were not available, the regional boundaries of suitable sources were extended to cover the missing area. In regions with no data coverage that could not be suitably extrapolated by the extension of a single data source, source averages were used to complete the coverage (ENVIRON, 2012).

The county level data was aggregated to generate basin level averages for the 11 onshore basins of the 13 shown in **Figure 1**. The relevant parameters pertaining to conventional gas well and coal bed methane production were aggregated weighted by the county level well count and average, minimum and maximum values are available in the associated *DS_Stage1_O_NG_Extraction_ProducedWaterTank_2014.01.xlsx* document. These basin and well type specific parameters are selected through the Parameter Scenario worksheet (PS). Due to the source limitations in the O&G database the minimum and maximum parameters should not be considered as an uncertainty range, but an expected range of possible values. The reasoning behind this being that regions with fewer extrapolated, or averaged, data sources will tend to have more agreement in parameter values between counties without providing any more certainty in the data.

The regionally averaged parameter values are used in equations provided in the 2011 Oil and Gas Emission Inventory Enhancement Project for CenSARA States report produced by ENVIRON and Eastern Research Group (ERG) in order to determine the average emission rate per well-year from produced water tanks. These emission rates were then obtained per-Molar natural gas produced by calculating the average emission rates weighted over water production and dividing by the average well production rate and density of natural gas.

This unit process utilizes the Environmental Protection Agency's (EPA) Oil and Gas Emission Estimation Tool (O&G Tool). This tool exists as a Microsoft® Access® database containing county level data on natural gas production, well counts, device counts, and various device characteristics. The O&G Tool was developed by compiling data from 49 sources including state and basin level sampling studies, federal reports and expert correspondences. Where better data were not available, the regional boundaries of suitable sources were extended to cover the missing area. In regions with no data coverage that could not be suitably extrapolated by the extension of a single data source, source averages were used to complete the coverage (ENVIRON, 2012).

The county level data were aggregated to generate basin level averages for the 11 onshore basins of the 13 shown in **Figure 1**. The relevant parameters pertaining to conventional gas well and coal bed methane production were aggregated weighted by the county level produced water production. Average, minimum and maximum values are available in the associated *DS_Stage1_O_NG_Extraction_Fugitive_Conn_2014.01.xlsx* document. These basin and well type specific parameters are selected through the Parameter Scenario worksheet (PS). Due to the source limitations in the O&G database the minimum and maximum parameters should not be considered as an uncertainty range but an expected range of possible values. The reasoning behind this being that regions with fewer, extrapolated, or averaged data sources will tend to have more agreement in parameter values between counties without providing any more certainty in the data.

Very few counties report having produced water, although technologically, this could not be the case. Therefore, it is assumed that this occurred because wells do not report produced water to the states or other data sources the Oil and Gas tool is using. Therefore, counties that do report zero produced water are not included in the data. However, none of the counties in the Central basin report any produced water for their CBM wells, leading to a region that produces CBM gas with no data about the produced water. In order to avoid this, the boundaries of the Central Region were extended (in the Produced Water UP only) to include four neighboring counties that do report produced water. See **Figure 2** for a map of the regions and the counties that were used to represent the Central Region for the Produced Water UP.

The regionally averaged parameter values are used in equations provided in the 2011 Oil and Gas Emission Inventory Enhancement Project for CenSARA States report produced by ENVIRON and Eastern Research Group (ERG) in order to determine the average emission rate per well-year from connections. These emission rates were then obtained per-mass natural gas produced by dividing by the average well production rate and density of natural gas. There are data available within the O&G Tool to determine the emission rates of carbon dioxide (CO_2), methane (CH_4), hydrogen sulfide (H_2S), and volatile organic compounds (VOC). The summation of total organic compounds weight fractions does not reach unity so the remainder was defined as nitrogen and ethane in a ratio determined from a 2011 memorandum utilized in the development of the O&G Tool (Pring, 2014) (Brown, 2011). The weight fractions originally presented as a ratio to total organic compounds were normalized to be on

a basis of total natural gas emitted. Additionally, the molecular weight of the emitted gas that is used to determine the gas density is calculated using the extended gas composition rather than using the one provided in the O&G Tool. Minimal speciation of C6+ VOC compounds is provided in the O&G Tool so the VOC weight fraction was further speciated using the SPECIATE database. **Figure 3** illustrates the unit process scope and boundary.

While the natural gas composition is calculated in this unit process, this information is only used to calculate the density of the natural gas in order to determine the total mass of natural gas emitted. This tracked output is intended to be connected to the Stage1_O_NG_Flaring UP which contains regionally and device specific gas compositions as parameter scenarios and accounts for the specific gas species being emitted to the atmosphere.

Figure 1: U.S. Basin Map

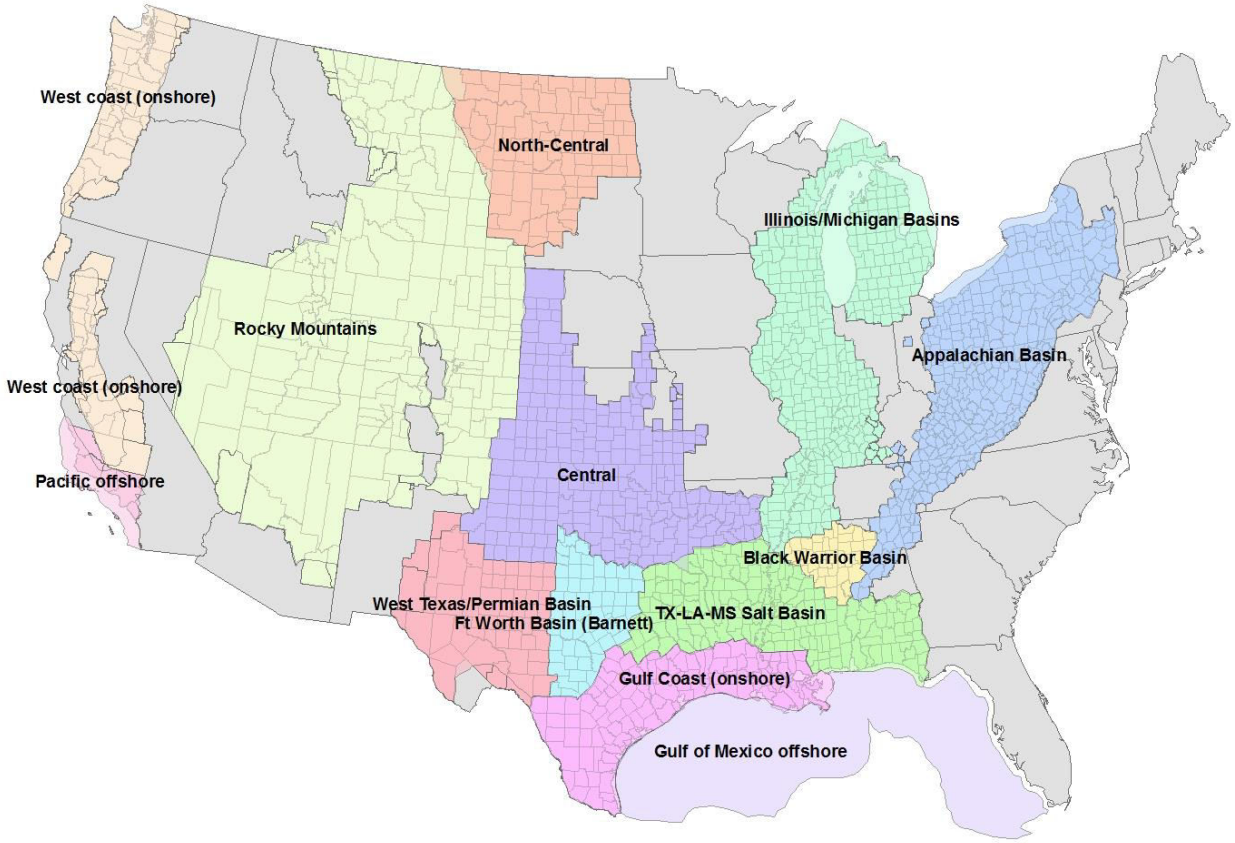

Figure 2: Map of Regions used for analysis, with counties that report produce water production highlighted in white and the counties used to represent the Central Region Produced water bordered in thick blue lines.

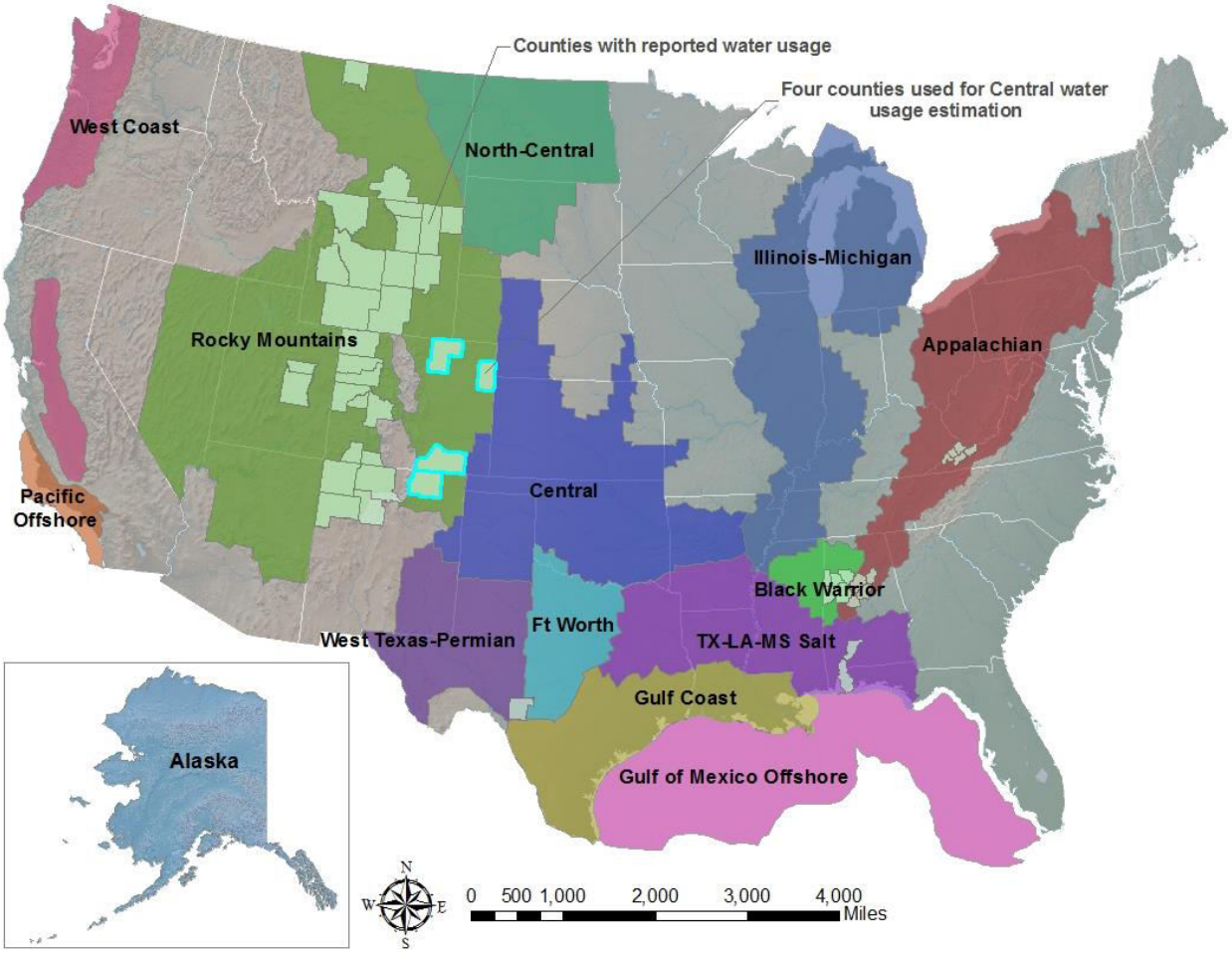

Figure 3: Unit Process Scope and Boundary

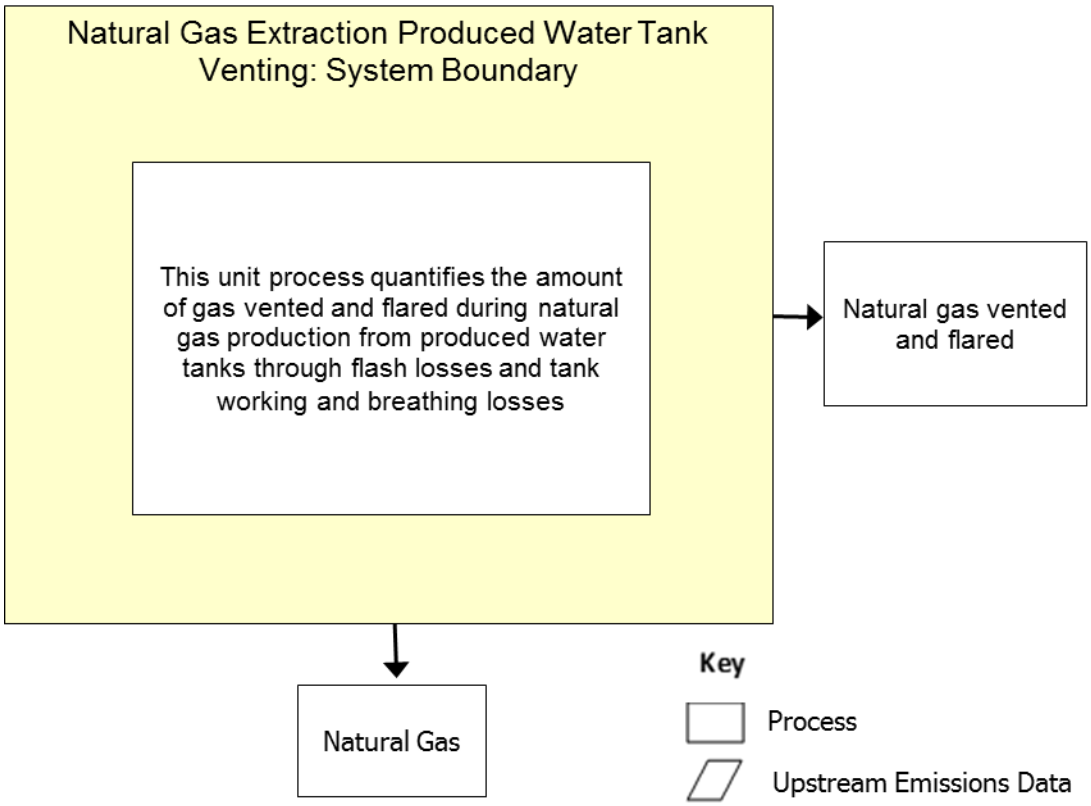

Table 1: Adjustable Parameters – Appalachian Basin – Gas Well

Parameter Name	Value	Min. Value	Max. Value	Units
MCF_Prod	2.23E+04			MCF/Well
PW_Prod	2.21E+02			bbl/Well
Tank_Frac	1.00E+00			dimensionless
EF_CH4	1.12E-01			lbs/bbl
WF_CH4	7.24E-01			kg/kg
MW_Gas	1.87E+01			kg/kmol

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Natural Gas [intermediate flow]	**1.00E+00**	
Natural Gas Vented, CondTank [Intermediate flow]	**3.20E-05**	**kg**

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Note: Inventory items not included are assumed to be zero based on best engineering judgment or assumed to be zero because no data was available to categorize them for this unit process at the time of its creation.

Embedded Unit Processes

None.

References

ENVIRON, 2012 — ENVIRON, Eastern Research Group (ERG). 2012. 2011 Oil and Gas Emission Inventory Enhancement Project for CenSARA States. Retrieved from www.censara.org/filedepot_download/56064/14 on August 8, 2014.

EPA, 2013 — Environmental Protection Agency (EPA). 2013. Oil and Gas Emission Estimation Tool. Retrieved from http://www.epa.gov/ttn/chief/net/2011inventory.html on August 8, 2014.

Section III: Document Control Information

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