Revisions Under Consideration for the 2018 GHGI Uncertainty Estimates

Stakeholder Workshop

June 22, 2017

Overview

- Background
- Methodology
- Results
- Request for stakeholder feedback

Background

- Prior uncertainty analysis done in 2010 for 2011 GHGI
  - Uncertainty for most EFs and AFs based on EPA/GRI study and expert judgment
- Since 2010
  - Changes in GHGI methodology and data sources
  - Changes in industry practices and equipment
  - Availability of new data
- New draft uncertainty analysis with 2017 GHGI data
- Updated approach would be included in 2018 GHGI

Methodology

- Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (2006)
- **Goal 1:** Develop 95% confidence bounds around average EF and AF for each source category
- **Goal 2**: Improve/strengthen uncertainty analysis methods and data used

Methodology (cont.)

- **Step 1:** Identified top sources that cover at least 75% of gross emissions in natural gas and petroleum systems for year 2015, based on 2017 GHGI
  - Natural Gas – top 14 sources cover 77% of emissions
  - Petroleum – top 5 sources cover 79% of emissions

Methodology (cont.)

Top 14 Natural Gas Systems CH4 Emission Sources in the 2017 GHGI

Emission Source (segment)	Year 2015 Gross Emissions (MMT CO2 Eq.)	% of Source Category Emissions
G&B stations (production)	49.2	27%
Pneumatic controllers (production)	25.5	14%
Station total fugitives (transmission)	14.3	8%
Engine combustion (transmission)	6.3	3%
Engine combustion (production)	6.3	3%
Engine combustion (processing)	5.8	3%
Liquids unloading (production)	5.2	3%
G&B episodic events (production)	4.9	3%
Pipeline venting (transmission and storage)	4.6	3%
G&B pipeline leaks (production)	4.0	2%
Station venting (transmission)	3.8	2%
Shallow water offshore platforms (production)	3.1	2%
Chemical injection pump venting (production)	3.0	2%
Separator fugitives (production)	2.9	2%
Subtotal, Top Sources	**139.1**	**77%**
Natural Gas Systems Total	**181.1**	**100%**

Top Five Petroleum Systems CH_4 Emission Sources in the 2017 GHGI

Emission Source (segment)	Year 2015 Gross Emissions (MMT CO2 Eq.)	% of Source Category Emissions
Pneumatic controllers (production)	18.6	48%
Shallow water offshore platforms (production)	4.2	11%
Associated gas venting and flaring (production)	3.7	9%
Engine combustion (production)	2.3	6%
Oil tanks (production)	2.0	5%
Subtotal, Top Sources	**30.8**	**79%**
Petroleum Systems Total	**39.0**	**100%**

Methodology (cont.)

- **Step 2:** Examined all underlying data sources used in estimating average EF and AF for each top-source category
- **Step 3:** Characterized the probability density function (PDF) for each applicable parameter via
  - Bootstrapping analysis of GHGRP Subpart W data
  - Using estimates from published studies, e.g., Marchese et al. (2015), Zimmerle et al. (2015), EPA/GRI (1996), etc.
  - Applying expert judgment, per IPCC guidance
- **Step 4:** Estimated 95% confidence intervals around the mean emission estimate for each of the top sources using Monte Carlo simulation

Select PDFs Used in the Uncertainty Analysis

Source Category	Parameter	Source	Comments	PDF
G&B Stations (Production)	EF (Scfd/Station)	Marchese, et al. (2015)	Statistical analysis of study data	Normal Mean = 53,066 Stdev = 2,468
Low-bleed Pneumatic Controllers (Production)	EF (Scfd/Controller)	Subpart W RY2015 & EPA/GRI (1996)	Statistical analysis of reported Subpart W data; PDF per expert judgment; statistical parameters for emission rate imputed using the reported 90% confidence bound in EPA/GRI study	Normal Mean = 23 Stdev = 10
Pipeline Venting (Transmission and Storage)	AF (Transmission Pipeline Miles)	PHMSA (2015)	PHMSA publication default, 1%	Uniform Min = 298,731 Max = 304,765
Engine Combustion (Production)	MMHPhr (For All Gas Wells in 1992)	EPA/GRI (1996)	PDF per expert judgment; statistical parameters imputed using the reported 90% confidence bound	Lognormal Mean = 27,460 Stdev = 32,531

More on PDFs

- National emissions in the GHGI are modeled as

  Average EF × **Average** AF

- PDFs developed intended to characterize the distribution of these **average** EFs and AFs
- The Central Limit Theorem (CLT) states that

  "The means of random samples drawn from a population with any type of distribution will be normally or near-normally distributed, provided that the sample on which these factors are based are unbiased (e.g., each population element, such as a facility or device, has an equal probability of being sampled) and is of sufficient size if the sample size is large enough (Mendenhall, Wackerly, & Scheaffer, 1990)."

- The distribution of sample means is different than a population distribution
- The underlying population from which the random samples are drawn may be non-normal but the means of random samples can still be normally distributed
- Most PDFs used in the uncertainty analysis are normally distributed in alignment with CLT principles

Natural Gas Systems Draft Update Results

Emission Source		Mean Year 2015 Emissions (MT CO_2 Eq.)	2.5% Lower Bound of Mean Year 2015 Emissions (MT CO_2 Eq.)		97.5% Upper Bound of Mean Year 2015 Emissions (MT CO_2 Eq.)	
			Value	%	Value	%
G&B Stations (Production)		49,192,568	44,624,214	-9%	53,751,668	9%
Pneumatic Controllers (Production)	High-bleed Pneumatic Controllers	2,368,036	1,127,456	-52%	3,976,192	68%
	Intermittent-bleed Pneumatic Controllers	22,380,215	12,745,236	-43%	33,762,516	51%
	Low-bleed Pneumatic Controllers	757,911	123,611	-84%	1,600,761	111%
	Subtotal	**25,506,161**	**13,996,303**	**-45%**	**39,339,469**	**54%**
Station Total Fugitives (Transmission)	Station, Incl. Compressor Components	2,934,282	2,998,572	2%	5,893,251	101%
	Reciprocating Compressors	8,484,047	8,113,652	-4%	18,712,780	121%
	Centrifugal Compressor (Wet Seals)	1,424,742	1,330,850	-7%	3,181,959	123%
	Centrifugal Compressor (Dry Seals)	1,467,867	1,364,200	-7%	3,289,167	124%
	Subtotal	**14,310,937**	**13,807,274**	**-4%**	**31,077,158**	**117%**
Engine Combustion (Production)		6,323,058	451,872	-93%	22,799,143	261%
Engine Combustion (Transmission)		6,299,036	2,107,162	-67%	8,312,883	32%
Engine Combustion (Processing)		5,806,032	1,961,980	-66%	7,381,227	27%
G&B Episodic Events (Production)		4,879,055	190,554	-96%	25,996,939	433%
Pipeline Venting (Transmission and Storage)		4,590,999	1,213,464	-74%	6,321,547	38%
G&B Pipeline Leaks (Production)		4,038,975	1,448,235	-64%	7,190,027	78%
Station Venting (Transmission)		3,849,139	1,072,316	-72%	10,306,627	168%
Chemical Injection Pump Venting (Production)		3,034,943	2,000,869	-34%	4,109,285	35%
Liquids Unloading With Plunger Lift (Production)		3,016,831	2,521,706	-16%	3,535,875	17%
Liquids Unloading Without Plunger Lift (Production)		2,211,607	1,681,552	-24%	2,739,094	24%
Shallow Water Offshore Platforms (Production)		3,086,499	452,253	-85%	5,698,836	85%
Separator Fugitives (Production)		2,924,891	1,738,168	-41%	4,201,238	44%
Total for Sources Modeled in Uncertainty Assessment		**139,070,729**	**89,267,920**	**-36%**	**232,761,014**	**+67%**
Total for Sources Not Modeled in Uncertainty Assessment		**23,354,602**	**14,991,053**	**-36%**	**39,088,317**	**+67%**
Source Category Total		**162,425,331**	**104,258,973**	**-36%**	**271,849,330**	**+67%**

Petroleum Systems Draft Update Results

Emission Source		Mean Year 2015 Emissions (MT CO2 Eq.)	2.5% Lower Bound of Mean Year 2015 Emissions (MT CO2 Eq.)		97.5% Upper Bound of Mean Year 2015 Emissions (MT CO2 Eq.)	
			Value	%	Value	%
Pneumatic Controllers (Production)	High-bleed Pneumatic Controllers	2,126,086	635,320	-70%	4,175,097	96%
	Intermittent-bleed Pneumatic Controllers	15,887,354	7,674,488	-52%	26,842,275	69%
	Low-bleed Pneumatic Controllers	619,806	79,695	-87%	1,436,872	132%
	Subtotal	**18,633,247**	**8,389,503**	**-55%**	**32,454,244**	**74%**
Shallow Water Oil Platforms (Production)		**4,207,887**	**1,052,724**	**-75%**	**11,578,951**	**175%**
Associated Gas Flaring & Venting (Production)	Associated Gas Flaring	2,642,647	1,180,379	-55%	4,430,285	68%
	Associated Gas Venting	1,062,962	79,843	-92%	2,623,880	147%
	Subtotal	**3,705,610**	**1,260,222**	**-66%**	**7,054,166**	**90%**
Oil Tanks (Production)	Large Oil Tanks with Flares	202,495	83,698	-59%	337,425	67%
	Large Oil Tanks with VRU	99,012	13,183	-87%	206,330	108%
	Large Oil Tanks without Controls	1,443,504	595,372	-59%	2,475,665	72%
	Small Oil Tanks with Flares	1,726	277	-84%	4,972	188%
	Small Oil Tanks without Controls	115,514	4,920	-96%	370,501	221%
	Large Oil Tank Separators with Malfunctioning Dump Valves	149,605	22,046	-85%	524,525	251%
	Subtotal	**2,011,857**	**719,495**	**-64%**	**3,919,418**	**95%**
Gas Engine Combustion (Production)		**2,254,932**	**33,122**	**-99%**	**7,195,582**	**219%**
Total for Sources Modeled in Uncertainty Assessment		**30,813,532**	**11,455,066**	**-63%**	**62,202,361**	**+102%**
Total for Sources Not Modeled in Uncertainty Assessment		**9,062,042**	**3,368,854**	**-63%**	**18,293,274**	**+102%**
Source Category Total		**39,875,574**	**14,823,920**	**-63%**	**80,495,635**	**+102%**

Summary

Analysis	Natural Gas Systems		Petroleum Systems	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
2011 Analysis	-19%	+30%	-24%	+149%
2018 Draft Update	-36%	+67%	-63%	+102%

- Wider bounds for natural systems in 2018 GHGI analysis
- Larger lower bound but smaller upper bound for petroleum systems in 2018 draft update

Requests for Stakeholder Feedback

1. Appropriateness of performing a detailed uncertainty analysis for "top" sources that cover a specified percent (e.g., 75%), and applying the same confidence interval to the remaining sources
2. Availability of additional information and data to characterize uncertainty parameters
3. How to compare uncertainty ranges from different studies and measurement/calculation approaches

Requests for Stakeholder Feedback

5. Additional steps that could be taken to improve characterization of the PDFs for data sources for which:
   a. Sample sizes are small
   b. The sampling methodology was biased (e.g., not nationally representative)
   c. Only certain statistical parameters (e.g., mean and std. dev) were available
6. Approaches to improve characterization of extreme distributions
7. Appropriateness of default uncertainty bounds
8. How improved uncertainty results can be used to target improvements in the GHGI