Overview of Updates Under Consideration for the 2018 GHGI—New Analyses

EPA GHG Data Stakeholder Workshop
October 27, 2017

Outline

- Abandoned Wells
- CO_2 Updates
- Uncertainty Analysis

Abandoned Wells Revision Under Consideration for the 2018 GHGI

Overview

- Available data
- Summary of stakeholder feedback
- Approaches under consideration and CH_4 emissions estimates
- Requests for stakeholder feedback
- Next steps

Available Data

Recent Direct Measurement Studies

- Kang et al. 2016
  - Measurements of 88 wells in Pennsylvania
  - Large differences in emissions rates observed for: well type (gas versus oil or co-producing), plugging status (plugged versus unplugged), and coal area designation
- Townsend-Small et al. 2016
  - Measurements of 138 wells in the Powder River Basin (WY), Denver-Julesburg Basin (CO), Uintah Basin (UT), and Appalachian Basin (OH)
  - Large differences in emissions rates observed for: plugging status (plugged versus unplugged), and eastern vs. western U.S.

Total Abandoned Wells Activity

- Use DrillingInfo data set to count number of wells existing but no longer reporting production as of [year].
  - Analyze LAST_PROD_DATE
- DrillingInfo does not have complete data for years before mid-1900s.
  - EPA estimated that 1.15 million abandoned wells are not captured in the DrillingInfo-based approach, by analyzing year 1975 data from historical records.
  - EPA would add the 1.15 million well count to the DrillingInfo-based total to develop an accurate count of abandoned wells existing in each year of the time series.

Plugging Status Activity Factor

- If EPA uses separate EFs for plugged vs. unplugged status, a split between the two populations is needed for the 1990–2016 time series.
  - DrillingInfo provides a snapshot of the "status" of all wells. EPA provided an example wherein the data are interpreted to estimate 69% of wells (in the database, which excludes very old wells) are unplugged in 2016.
  - EPA might assume 100% unplugged status for wells in a certain early year—e.g., 1950—based on historical literature documenting effectiveness of plugging approaches over time (NPC 2011).
  - EPA might interpolate to develop plugged vs. unplugged split each year 1950–2016.

Summary of Stakeholder Feedback

National Emissions Estimation Approaches Under Consideration

Activity Data

1. Use DrillingInfo database, and estimate wells not included in DrillingInfo to develop activity over the 1990-2016 time series
    - Refer to EPA memo for additional detail, including documentation of estimated 1.15MM wells not captured in DrillingInfo-based analysis
2. Develop plugged vs. unplugged split over the time series based on analysis previously presented
    - Refer to EPA memo for additional detail on considerations regarding state orphaned well plugging programs

Draft 2018 GHGI Activity Data

Year	Abandoned Well Count (millions)			Plugging Status (%)	
	Total	Gas	Oil	Unplugged	Plugged
1990	2.37	0.32	2.05	81	19
1995	2.52	0.35	2.17	79	21
2000	2.67	0.37	2.30	77	23
2005	2.78	0.40	2.38	74	26
2010	2.91	0.45	2.46	72	28
2015	3.11	0.55	2.56	70	30
2016	3.35	0.72	2.63	69	31

Emissions Data

- Kang, et al. 2016 (all production types)

Data Set	Number of Measured Wells		Mean (g/hour/well)	
	Unplugged	Plugged	Unplugged	Plugged
All	53	35	22	15
Coal	17	12	1.2	43
Noncoal	36	23	31	0.45

- Townsend-Small, et al. 2016

Data Set	Number of Measured Wells		Mean (g/hour/well)	
	Unplugged	Plugged	Unplugged	Plugged
Entire U.S.	19	119	10.02	0.002
Eastern U.S.	6	6	28.01	0
Western U.S.	13	113	1.71	0.002

- Combined Appalachia ("Noncoal" Pennsylvania and "Eastern U.S." (Ohio))

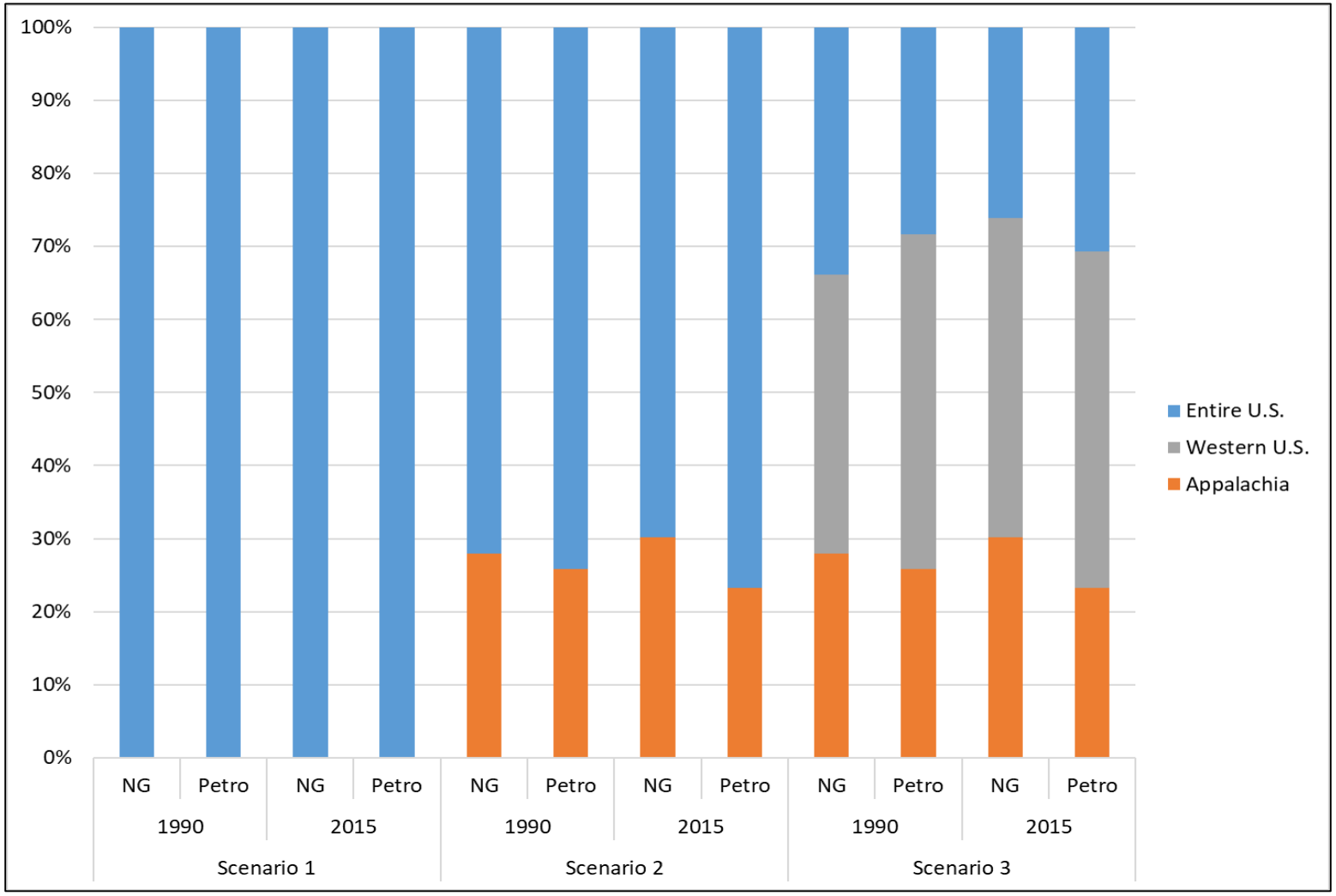
Data Set	Number of Measured Wells		Mean (g/hour/well)	
	Unplugged	Plugged	Unplugged	Plugged
Appalachia	42	29	30.6	0.4

Emissions Estimation Approaches

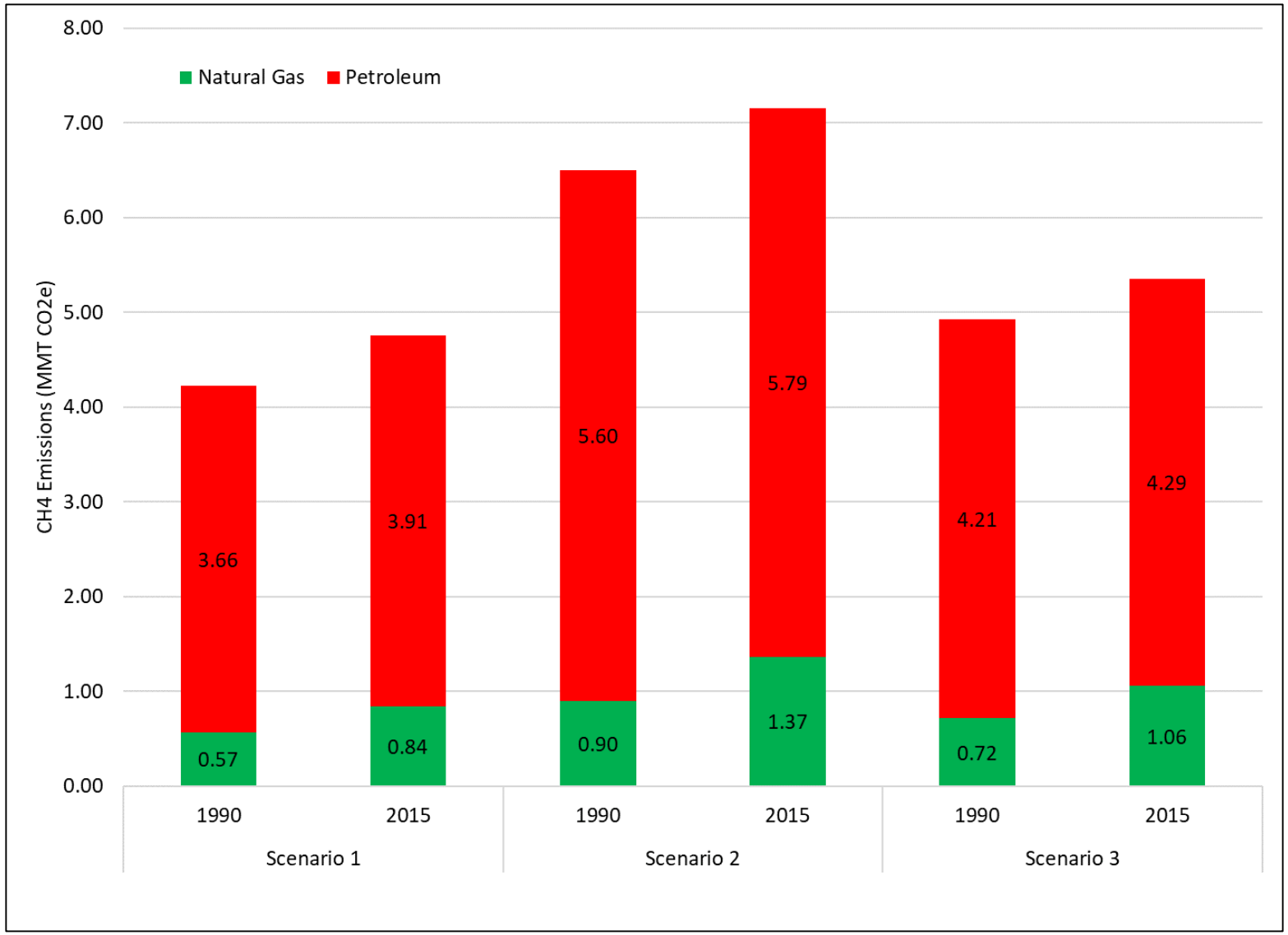
EPA calculated estimates for three scenarios to assess a range of expected emissions from abandoned wells.

- Scenario 1 (previously presented):
  - Townsend-Small "entire U.S." EFs apply to all abandoned wells
- Scenario 2:
  - "Appalachian" EFs apply to abandoned wells in the Appalachian Basin region
  - Townsend-Small "entire U.S." EFs apply to all other abandoned wells
- Scenario 3:
  - "Appalachian" EFs apply to abandoned wells in the Appalachian Basin region
  - Townsend-Small "entire U.S." EFs apply to abandoned wells in Texas
  - Townsend-Small "western U.S." EFs apply to all other abandoned wells

Fraction of Abandoned Wells in Each EF Category, by Scenario



Estimates of Abandoned Well CH_4 Emissions over GHGI Time Series, for Multiple Scenarios (MMT CO_2e)



Requests for Stakeholder Feedback

Requests for Stakeholder Feedback (Refer to EPA memo for details)

1. Are additional data sources available for abandoned wells?
   - Emissions data?
   - Population of wells abandoned prior to 1990 (considering that the production phase of many such wells likely pre-dates DrillingInfo coverage)?
   - Split between plugged and unplugged wells existing in each year of the time series (1990–2016)?
2. How might the EFs presented on Slide 10 be used to estimate national emissions? EPA seeks stakeholder feedback on which scenario using "Entire U.S.", "Appalachian" and "Western U.S." EFs best represents U.S. emissions from abandoned wells, or alternative approaches to consider.
3. Which subcategories of abandoned wells should be represented in the GHGI (taking into account data availability and differences between emissions rates for subcategories)?

Requests for Stakeholder Feedback (Refer to EPA memo for details) – cont.

6. EPA might use year 2015 abandoned well counts as a surrogate estimate for year 2016, and a similar approach in future GHGIs. EPA seeks feedback on this approach or other approaches to consider.
7. What year (e.g., 1950) might be appropriate to assume that zero percent of existing abandoned wells were effectively plugged (such an estimate would serve as a tie point for use in interpolation to develop plugged versus unplugged activity factors)?
8. Are there any additional ongoing or planned studies related to abandoned wells that could be used to refine future GHGIs?
9. Are data sources available to estimate emission factors for related derelict infrastructure (e.g., flow lines)?

Next Steps

Next Steps

1. Review stakeholder feedback on emissions estimation approaches under consideration, specifically use of region-specific EFs.
2. Include draft estimate in public review draft GHGI for additional feedback

CO_2 Revisions Under Consideration for the 2018 GHGI

Overview

- Available subpart W data
- CO_2 revisions under consideration
- Summary of stakeholder feedback
- Approaches to analyze regional differences in associated gas venting and flaring
- Next steps

Available Subpart W Data

- Subpart W activity and emissions data are used in the current GHGI to calculate CH_4 emissions for several production, processing, and transmission and storage sources
- For these sources, CO_2 emissions data from subpart W have not yet been incorporated into the GHGI
- Facilities use an identical reporting structure for CO_2 and CH_4. Therefore, where subpart W CH_4 data have been used, the CO_2 data may be incorporated in an identical manner

Available Subpart W Data

- Subpart W data for AGR vents (CO_2) and flare stacks (both CH_4 and CO_2) have not been incorporated into GHGI
- Flare stacks data available for:
  - Production ("miscellaneous flaring") - reported under "flare stacks" source if emissions originate from sources not otherwise covered. For example, production tank flaring is reported under the tanks source and not under flare stacks
  - Transmission compression, underground natural gas storage, LNG storage and LNG import and export equipment. As of RY2015, all flaring emissions are reported under flare stacks

CO_2 Revisions Under Consideration

- Production
  - Associated Gas
  - Production Tanks
  - Miscellaneous Production Flaring
  - HF Gas Well Completions and Workovers
  - Pneumatic Controllers
  - Pneumatic Pumps
  - Liquids Unloading
- Processing
  - Grouped Sources (e.g., Flares, Compressors)
  - AGR
  - Blowdowns and Venting
- Transmission and Storage
  - Flares
  - Pneumatic Controllers

Summary of Stakeholder Feedback

National Emissions for 2015 (mt CO_2)

Industry Segment & Emission Source	Natural Gas Systems		Petroleum Systems	
	2017 GHGI	Draft Update	2017 GHGI	Draft Update
Production	**18,585,048**	**4,855,904**	**640,443**	**44,233,703**
Associated Gas	n/a	n/a	826	28,582,015*
Tanks	30,426	1,108,346	519,934	8,643,876
Miscellaneous Flaring	17,628,522	1,860,355	incl. w/NG	6,864,989
Gas HF Completions/Workovers	91,965	1,129,883	n/a	n/a
Other Production Sources	834,135	757,319	119,683	142,823
Processing	**23,713,206**	**20,826,478**	n/a	n/a
Transmission & Storage	**38,694**	**250,095**	n/a	n/a
Distribution	**13,988**	**13,988**	n/a	n/a
Refining	n/a	n/a	**2,926,666**	**2,926,666**
Source Category Total	**42,350,936**	**25,946,465**	**3,567,110**	**47,160,369**
Source Category Difference	**-16,404,470**		**+43,593,260**	

*Approach presented in June 2017. Additional approaches are being assessed.

Associated Gas: Regional Differences

- Based on stakeholder feedback, EPA has developed national CO_2 estimates by two different approaches, to consider how regional differences might be taken into account through varying levels of disaggregation.
- Approach 1: National-level EFs and AFs
  - Previously presented
- Approach 2: NEMS Region-level EFs and AFs
  - 6 regions
  - Basis for region-specific estimates for certain sources in current GHGI

Associated Gas: National-Level Approach

- CO_2 EFs from subpart W

Year	Flaring CO_2 EF (kg/well)
2015	510,909
2016	266,751

- Subpart W Activity Data

Year	% of Total that Vent or Flare	% that Vent	% that Flare
2015	12%	17%	83%
2016	15%	11%	89%

Associated Gas: NEMS Region-Level Approach

RY2015 Subpart W Data

- Range of coverage across the NEMS Regions
  - Range from 9–28% of national oil wells, and 7–83% of oil wells reported in W
  - Two regions (Rocky Mountain and South West) account for majority of associated gas emissions
- RY2016 data show similar patterns

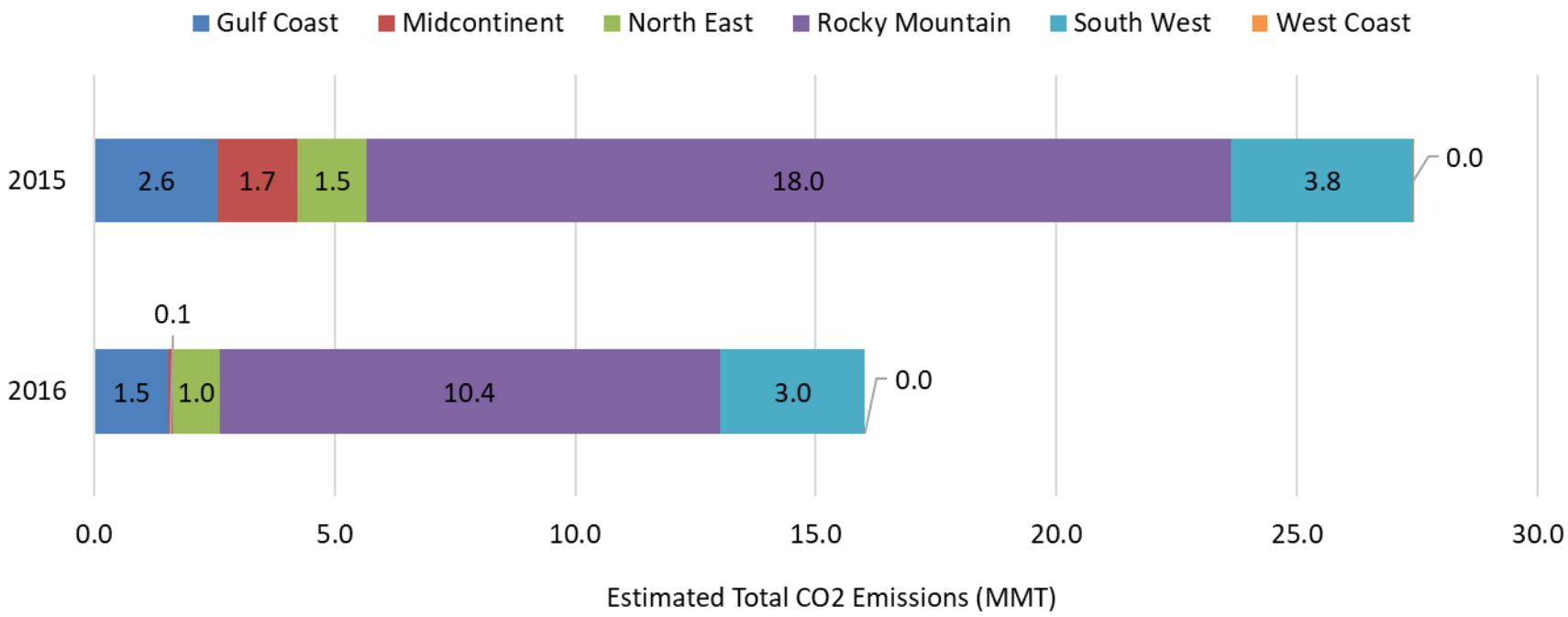
NEMS Region	National Data		Subpart W Data				
	# Oil Wells	% of Total Natl. Oil Wells	# Reported Oil Wells	% of NEMS Oil Wells Reported in Subpart W	# Assoc. Gas Venting & Flaring Wells	% of Assoc. Gas Venting & Flaring Wells	% of Total Reported CO_2e Emissions
Gulf Coast	87,516	15%	23,152	26%	1,853	7%	6%
Midcontinent	148,339	25%	16,110	11%	599	2%	2%
North East	65,196	11%	4,620	7%	261	1%	1%
Rocky Mountain	66,573	11%	29,933	45%	12,940	50%	72%
South West	167,767	28%	92,655	55%	9,627	37%	19%
West Coast	54,626	9%	45,148	83%	779	3%	0%
TOTAL	**590,017**	**100%**	**211,618**	**36%**	**26,059**	**100%**	**100%**

Associated Gas: NEMS Region-Level Approach

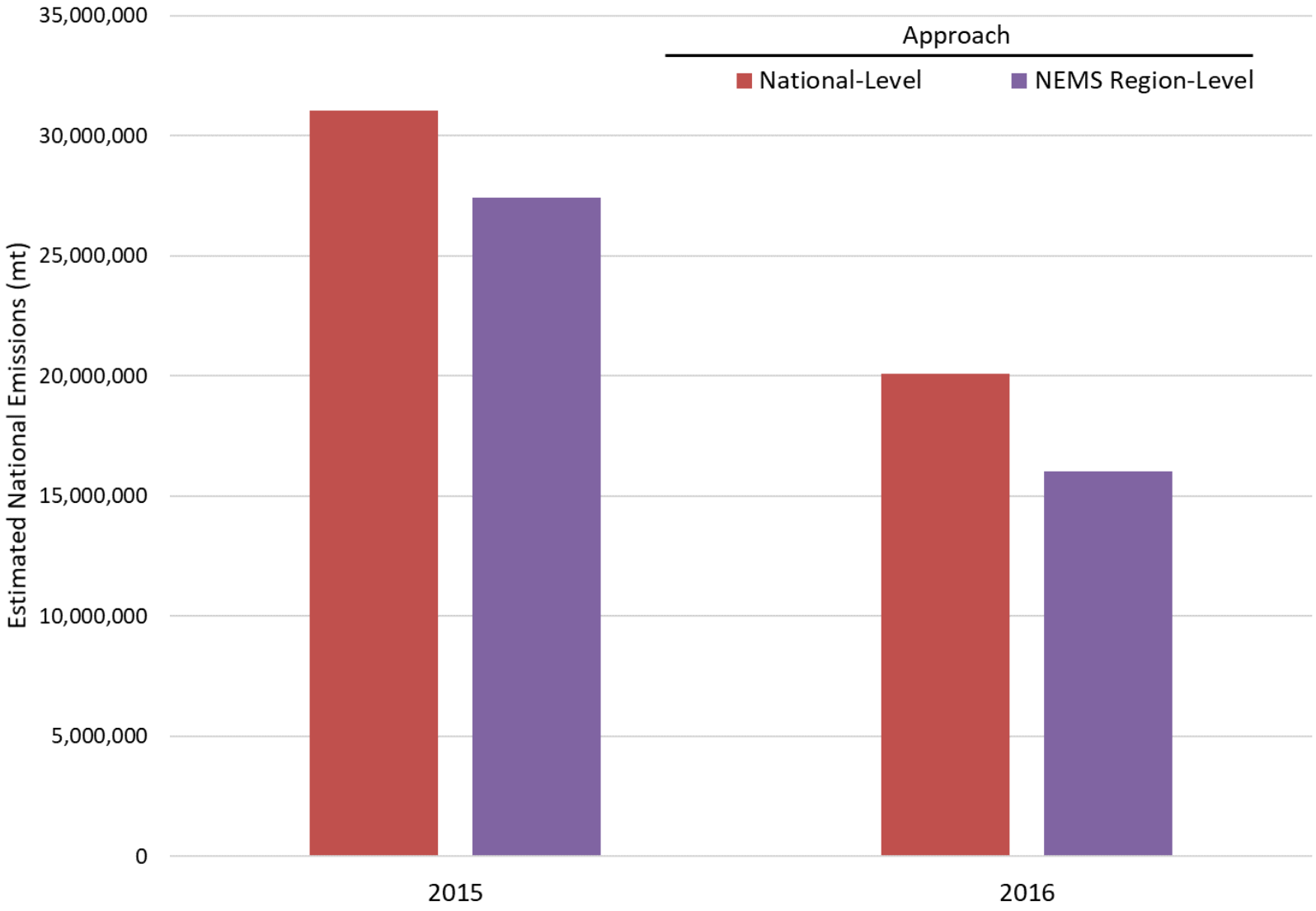
- A wide range of EFs and AFs are calculated for each NEMS Region
- Rocky Mountain (with ND) has notably high AF, where 40% of oil wells vent or flare associated gas, and 98% of these flare associated gas

NEMS Region	RY2015				RY2016			
	Flaring CO_2 EF (kg/well)	% of Total that Vent or Flare	% that Vent	% that Flare	Flaring CO_2 EF (kg/well)	% of Total that Vent or Flare	% that Vent	% that Flare
Gulf Coast	438,186	8%	17%	83%	285,149	8%	24%	76%
Midcontinent	1,659,300	4%	82%	18%	24,794	7%	64%	36%
North East	598,028	6%	34%	66%	337,635	7%	38%	62%
Rocky Mountain	634,770	43%	2%	98%	413,185	40%	2%	98%
South West	289,550	10%	25%	75%	129,346	16%	11%	89%
West Coast	3,053	2%	99%	1%	--	1%	100%	0%

Associated Gas: NEMS Region-Level Approach



Associated Gas: CO_2 Comparison



Associated Gas: Requests for Stakeholder Feedback

1. Which approach (national EF and AD, or regional EF and AD) best represents national emissions? Which alternative approaches suggested by stakeholders might better reflect regional variability and national emissions?
   - Should EPA consider an approach not discussed here?
2. For disaggregated approaches (NEMS region or another alternative), how should EPA assess whether sufficient data are reported to develop representative EFs and AFs?
   a. For regions without sufficient data, how should EPA develop EFs and AFs?
   b. What scale-up assumptions should EPA make regarding regions that do not report any associated gas venting or flaring (e.g., West Coast region reports no flaring in RY2016)? Should EPA assume that these states/regions have no such activity, or should EPA assign surrogate EF and AF values?

Next Steps

- For sources with existing CH_4 methodology
  - Implement CO_2 revisions under consideration into 2018 GHGI,
- Assess additional approaches and additional feedback on Associated Gas
- For sources without existing CH_4 methodology (Miscellaneous Production Flares and Transmission & Storage Flares)
  - Review RY2016 data and compare to RY2015; consider whether there are differences or notable trends
  - Implement CO_2 revisions under consideration into 2018 GHGI
  - Recognize compressor stations that serve both transmission and storage
- Include draft estimates in public review draft GHGI for additional feedback

Revisions Under Consideration for the 2018 GHGI Uncertainty Estimates

Overview

- Background
- Stakeholder Feedback
- Methodology Considerations
- Results
- Next steps

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 industry practices and equipment
  - Changes in GHGI methodology and data sources
- Draft uncertainty analysis with 2017 GHGI data was documented in a June 2017 memo

Stakeholder Feedback

- Consider applying propagation of error formulas in lieu of simple summation approach
- Consider limitations to uncertainty analysis
- Postpone update to uncertainty analysis until additional new data can be incorporated
- Updated uncertainty methodology considerations are presented today

Methodology

- The draft uncertainty methodology relies on performing a detailed uncertainty assessment for emission sources that contribute at least 75% of emissions for natural gas and petroleum systems (i.e., modeled, or “top”, sources).
- A detailed uncertainty assessment is not conducted for the remaining sources (i.e., unmodeled , or “non-top”, sources).

Methodology (cont.)

- There are 3 main steps to determine the source category total uncertainty:
  1. Calculate uncertainty for each modeled source
  2. Estimate uncertainty for <u>total</u> CH_4 from the unmodeled sources
  3. Combine uncertainty for the modeled and unmodeled sources to estimate source category total uncertainty
- EPA has evaluated additional considerations for steps 2 and 3 in response to stakeholder feedback
- IPCC guidance details two relevant calculation approaches:
  - Applying propagation of error formulas (IPCC Approach 1)
  - Monte Carlo simulation (IPCC Approach 2)

Step 1: Modeled Sources – Recap

Top 14 Natural Gas Systems CH_4 Emission Sources in the 2017 GHGI

Emission Source (segment)	Year 2015 Gross Emissions (MMT CO_2 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 5 Petroleum Systems CH_4 Emission Sources in the 2017 GHGI

Emission Source (segment)	Year 2015 Gross Emissions (MMT CO_2 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%**

Step 1: Uncertainty Calculation for Modeled Sources (cont.)

- Examined all underlying data sources used in estimating average EF and AF for each top-source category
- 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
- Estimated 95% confidence intervals around the mean emission estimate for each of the top sources using Monte Carlo simulation

Step 2: Estimate uncertainty for total CH_4 emissions from unmodeled sources

- **June 2017 Draft Approach:** Set the uncertainty bounds for non-top sources equal to the approximated uncertainty bounds for the total CH_4 emissions from top sources using simple summation
- **Propagation of Error Approach:** Set the uncertainty bounds for non-top sources equal to the uncertainty bounds for the total CH_4 emissions from top sources using propagation of error formulas
- **Monte Carlo Approach:**
  - *Alternative 1* - Perform a detailed uncertainty assessment for all not just top sources (Note: nearly 90 non-top sources in natural gas systems)
  - *Alternative 2* - Use Monte Carlo simulation by applying uncertainty data for modeled sources to unmodeled sources

Step 2: Estimate uncertainty for total CH_4 emissions from unmodeled sources (cont.)

- **Monte Carlo Approach (Alternative 2):** Use Monte Carlo simulation by applying uncertainty data for modeled sources to unmodeled sources
  - Estimate the nature of the probability density function (PDF) (e.g., normal, lognormal) along with its parameters (e.g., mean, standard deviation) for <u>total</u> CH_4 emissions from modeled sources
  - Adjust PDF and standard deviation for unmodeled sources as:

$$StdDev_{Non\text{-}top} = StdDev_{Top} \times (MeanCH4_{Non\text{-}top} / MeanCH4_{Top})$$

  - Use Monte Carlo simulation to calculate 95% uncertainty bounds for <u>total</u> CH_4 emissions from unmodeled sources

Step 3: Combine Uncertainty for Modeled and Unmodeled Sources

- **June 2017 Draft Approach:** Simple summation; results in identical 95% uncertainty bounds for modeled, unmodeled, and overall CH_4 emissions
- **Propagation of Error Approach:** Propagation of error formulas
- **Monte Carlo Approach:** Monte Carlo simulation (Alternative 2)

Results

Methodology	Natural Gas Systems		Petroleum Systems	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
June 2017 Draft (simple summation)	-39%	+59%	-62%	+100%
Propagation of Error Approach	-10%	+19%	-24%	+37%
Monte Carlo Approach	**-15%**	**+17%**	**-32%**	**+36%**

Next Steps

- Consider stakeholder feedback on the updated uncertainty methodology considerations
- Include draft uncertainty analysis results in public review draft of the 2018 GHGI
- In the 2018 GHGI report, discuss limitations of the current approach, including:
  - The potential for different or higher uncertainties across the time series based on the methods and assumptions used for emission factor and activity data development, e.g., interpolation
  - Unquantified modeling uncertainty