

NATURAL GAS & PETROLEUM SYSTEMS: UPDATES UNDER CONSIDERATION FOR 2024 GHGI

Stakeholder Webinar

October 3, 2023

AGENDA

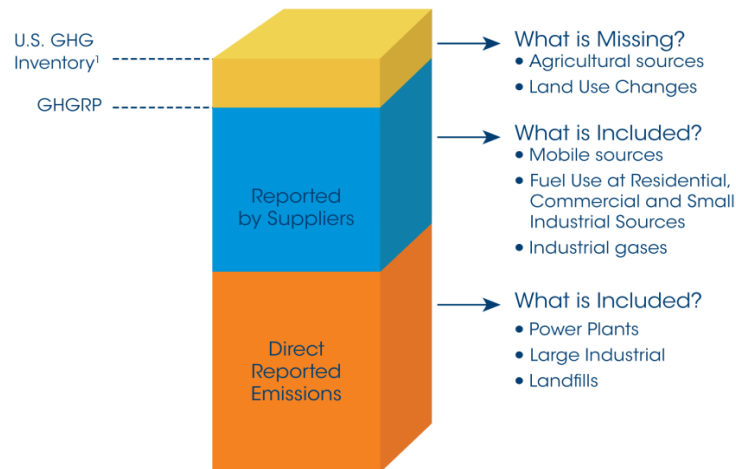
- GHG Inventory Overview
- Overview of State-level GHGI and Gridded CH₄ GHGI
- Updates Under Consideration for 2024 GHGI
 1. Transmission Compressor Station Activity Data
 2. Completions and Workover Emissions
 3. Underground Natural Gas Storage Emission Events

GHG INVENTORY OVERVIEW

EPA GHG DATA: U.S. GHG INVENTORY (GHGI) AND GHG REPORTING PROGRAM (GHGRP)

- Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI), the U.S. official GHG Inventory submission to UNFCCC, tracks total annual U.S. emissions across all sectors of the economy, using mostly national-level data
- GHGRP collects detailed emissions data from large greenhouse gas emitting facilities in the United States, as directed by the Clean Air Act
 - GHGRP covers most, but not all, U.S. GHG sources and sinks (i.e., GHGRP does not include agriculture, land use, and small sources)

GHGRP Covers the Majority of U.S. GHG Emissions



Task	Inventory of U.S. GHG Emission and Sinks	Greenhouse Gas Reporting Program
Find total U.S. emissions and sinks	✓	
Review trend data for the past 20+ years	✓	
Browse a map to find the largest emitters in your area		✓
Compare facility emissions across an industrial sector		✓
Find state-level data	Total ✓	Reported ✓

GHGI OVERVIEW

- **GHGI**

- Official U.S. Government data on national GHG emissions and sinks over time by gas, source/sink, and economic sector
- CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, and NF₃
- Fulfills U.S. reporting commitment under the UNFCCC
- Covers a time series beginning with 1990

- **Oil and Gas in the GHGI**

- IPCC fugitive emissions category; includes leaks, vents, and flaring emissions
- Oil and gas in GHGI covers hundreds of types of emission sources
- Emissions calculated using data from GHGRP, research studies, national level activity data, etc.

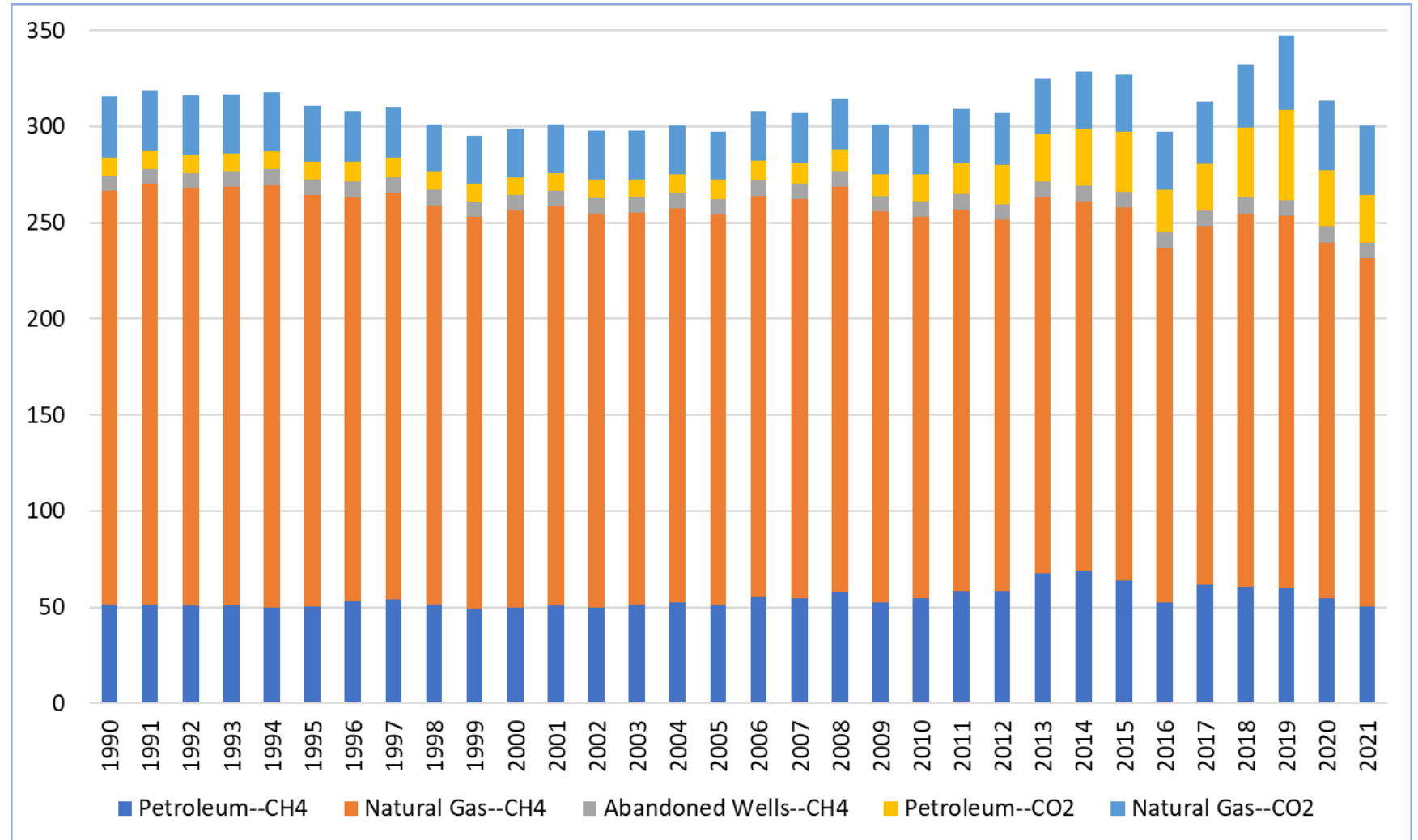
TRENDS IN CH₄ AND CO₂ EMISSIONS FROM OIL AND GAS SYSTEMS

1990-2021 Trends and Key Drivers

- CH₄-decrease of 13%
 - Distribution (upgrades to pipeline and stations)
 - Transmission and storage (changes in compressor types)
- CO₂-increase of 46%
 - Oil and gas production (increased flaring)

2020-2021 Trends and Key Drivers

- CH₄-decrease of 3%
 - Oil and gas production (decrease in emissions from pneumatic controllers)
- CO₂-decrease of 7%
 - Oil production (decreased flaring of associated gas)



EPA OIL AND GAS GHGI STAKEHOLDER PROCESS

- Annual stakeholder process to discuss new data and improvements to GHGI data
- Typically hold two webinars/workshops in the development of each GHGI
- Stakeholder website
(<https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems>)
 - Information on workshops and memos on updates under consideration
 - Full time series of data and information on methods

PREVIOUS UPDATES TO GHGI

Year	Update
2023	Implemented basin-level calculation methodologies using GHGRP data for select production sources
2022	Inclusion of post-meter estimates and large well blowouts, improved estimates for abandoned wells and voluntary reductions
2021	Updated data on customer meters and produced water
2020	Use of research study EFs for G&B equipment, use of BOEM and GHGRP data on offshore
2019	Use of GHGRP data for G&B and transmission pipelines, LNG, HF oil wells, N ₂ O emissions
2018	Inclusion of abandoned wells estimate, use of GHGRP for CO ₂ and year-specific EFs
2017	Inclusion of Aliso Canyon estimate, GHGRP for processing, associated gas venting and flaring,
2016	Update to production (GHGRP), G&B emission estimate, transmission (GHGRP and research study), distribution (GHGRP and research study)
2015	Use of GHGRP for refineries, use of latest BOEM for offshore, update to well data source
2014	Use of GHGRP data for HF gas wells
2013	Use of API/ANGA data on liquids unloading, use of NSPS OOOO analysis for gas wells

OVERVIEW OF STATE-LEVEL GHGI AND GRIDDED CH₄ GHGI

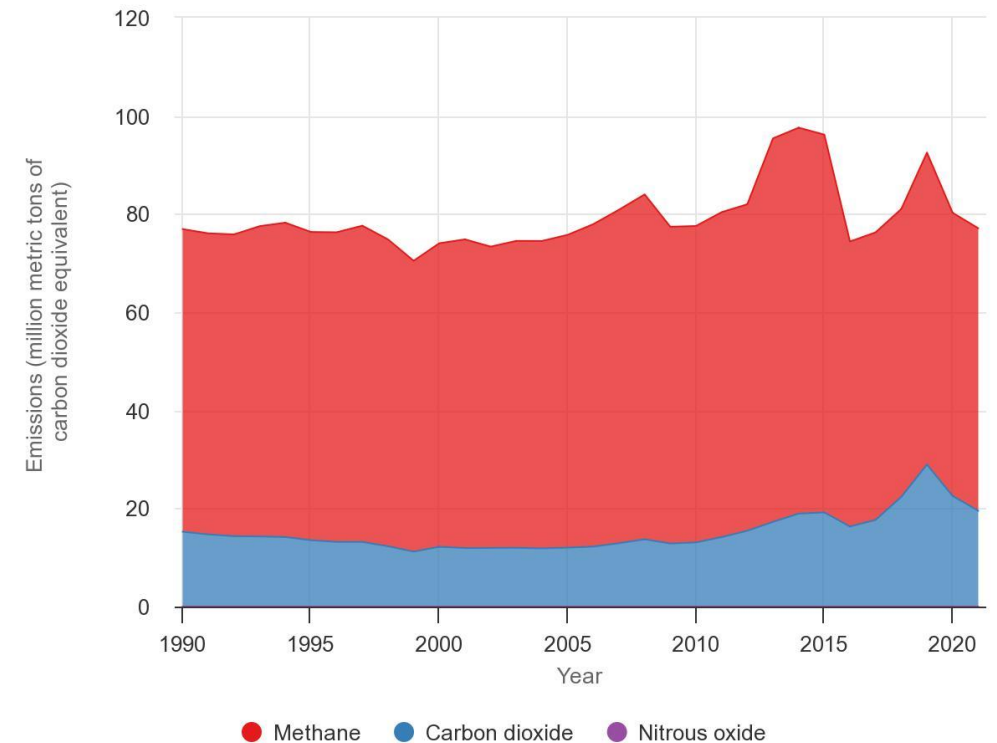
GHG STATE-LEVEL ESTIMATES FOR OIL AND GAS

Approach to allocate emissions to state-level

- National GHGI emissions are allocated to each state using datasets with state-specific data that are used to represent the relative contributions of state emissions to the national total
 - e.g., state-specific well counts, pipeline miles, production
- Approach reflects geographic variations for some sources
 - Basin-level inputs for liquids unloading, pneumatic controllers, equipment leaks, and tanks
 - State-specific data on pipeline materials, number and types of wells
- Approach does not reflect certain other variation
 - e.g., differences in technologies and practices, impacts of state regulations outside of those sources for which basin-level data are applied

Example: Texas

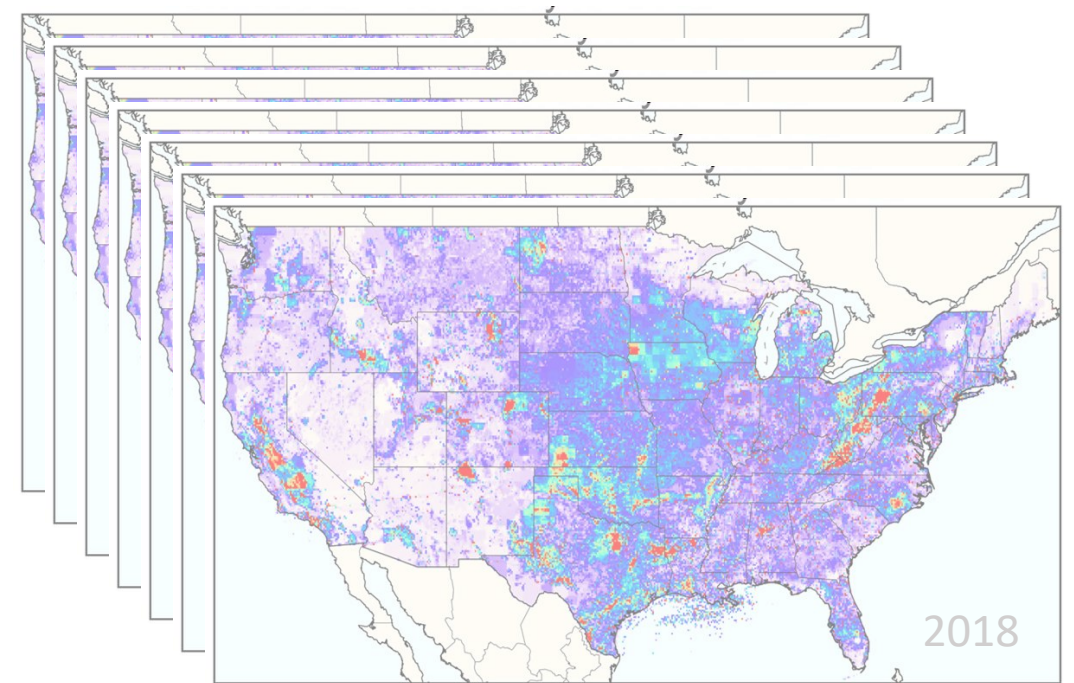
Texas Greenhouse Gas Emissions from Natural Gas and Petroleum Systems, by Gas, 1990–2021



Source: U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990–2021.
<https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals>

GRIDDED EPA METHANE EMISSIONS INVENTORY

- Spatially and temporally disaggregated version (~10 x 10 km, monthly resolution) of all methane emission sources in the GHGI
- Allows for more direct comparison between the GHGI and the time and location of atmospheric methane observations/emission rates
- Is used as a prior estimate for inversions of atmospheric methane



Version 1—Published 2016

- Emissions for 2012
- Based on 2016 GHGI
- Research study effort

Version 2—Published 2023

- Timeseries (2012 – 2018, and “express” data set to 2020)
- Based on 2020 GHGI
- Development of a system to streamline future updates

UPDATE UNDER CONSIDERATION FOR 2024 GHGI: TRANSMISSION COMPRESSOR STATION ACTIVITY

BACKGROUND

- Largest methane sources for the transmission and storage segment in the O&G GHGI include:
 - Compressor station equipment leaks (including compressor unit leaks)
 - Pipeline venting
 - Compressor station venting
 - Uncombusted compressor engine exhaust
- EPA is proposing to update components of the existing activity data (AD) methodology—national transmission station counts and counts of compressors per station
- Update under consideration impacts - equipment leaks at transmission compressor stations (including compressor units), station venting, flaring, pneumatic devices, and dehydrator vents

CURRENT GHGI METHODOLOGY

- National transmission station and compressor counts are developed using data from GHGRP and Zimmerle et al. (2015)
 - The Zimmerle et al. study estimated national CH₄ emissions from the transmission & storage segment for 2012
- **Transmission station counts**: GHGRP counts scaled to national level using a static factor of 3.52 (for 2011 forward) from Zimmerle study
- **Compressor counts**: 2.8 reciprocating compressors/station and 1.2 centrifugal compressors/station (from Zimmerle study)
 - Proportion of dry seal to wet seal centrifugal compressors from subpart W

For both station counts and compressor counts:

- 1990 – 1992 AD from 1996 EPA/GRI study
- 1993 – 2010 AD calculated using linear interpolation

REVIEW OF AVAILABLE DATA SOURCES

- Relevant data are available from FERC, Enverus, PHMSA, Homeland Security, GHGRP
- No data source includes a time series of total national transmission station or compressor counts
- EPA reviewed potential approaches for developing a national time series from the available data (e.g., using pipeline miles to scale up station counts, and using data sets to develop updated factors of compressors per station)

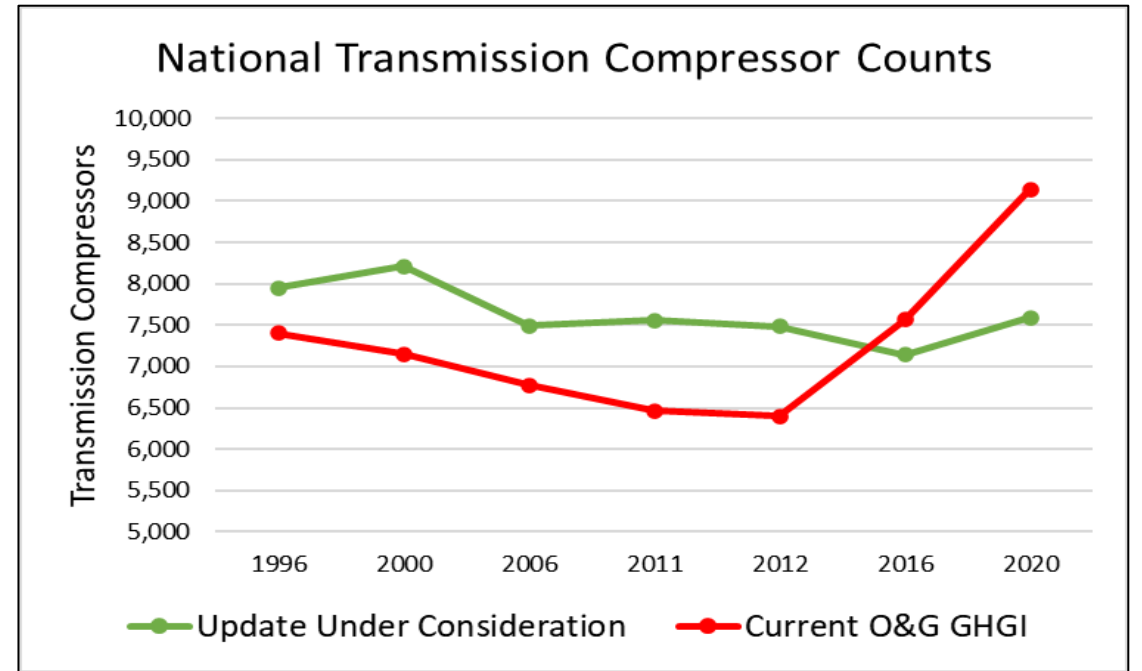
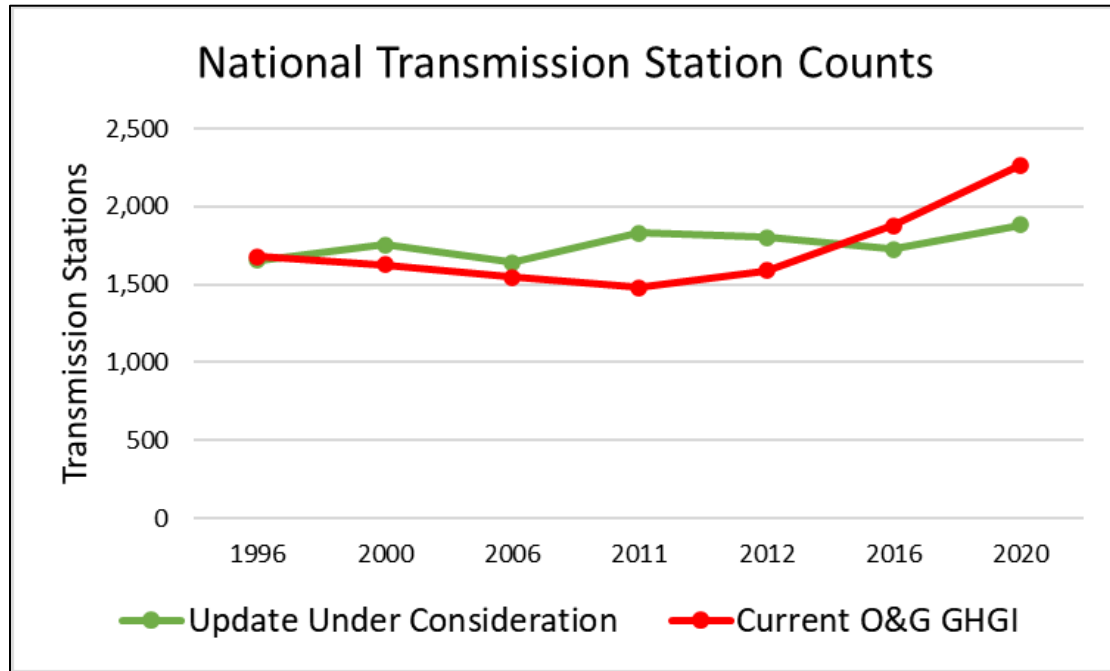
AVAILABLE DATA

	Compressor Stations	Compressor Units	Pipeline Miles	Scope	Years Available
FERC Form 2	X	X	X	Major Companies	1996 forward
Enverus Midstream	X		X	National	Current operations
Homeland Infrastructure Foundation-Level	X	X		National	Current operations
Subpart W	X	X (by type)	X	Over Reporting Threshold	2011 forward
PHMSA			X	National	Full time series

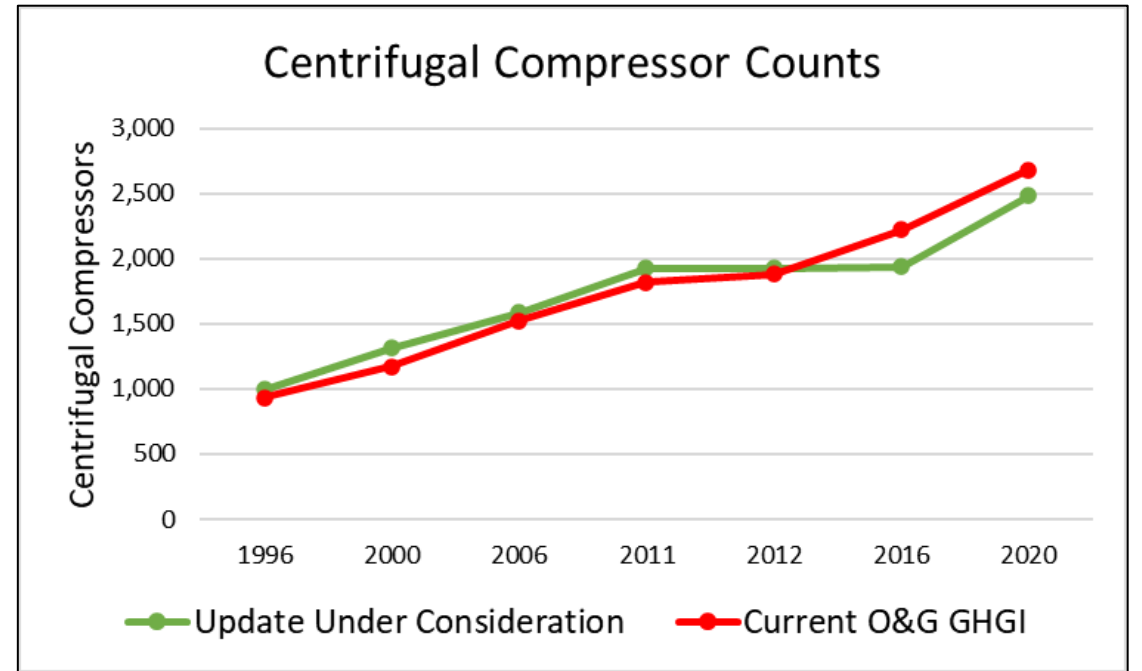
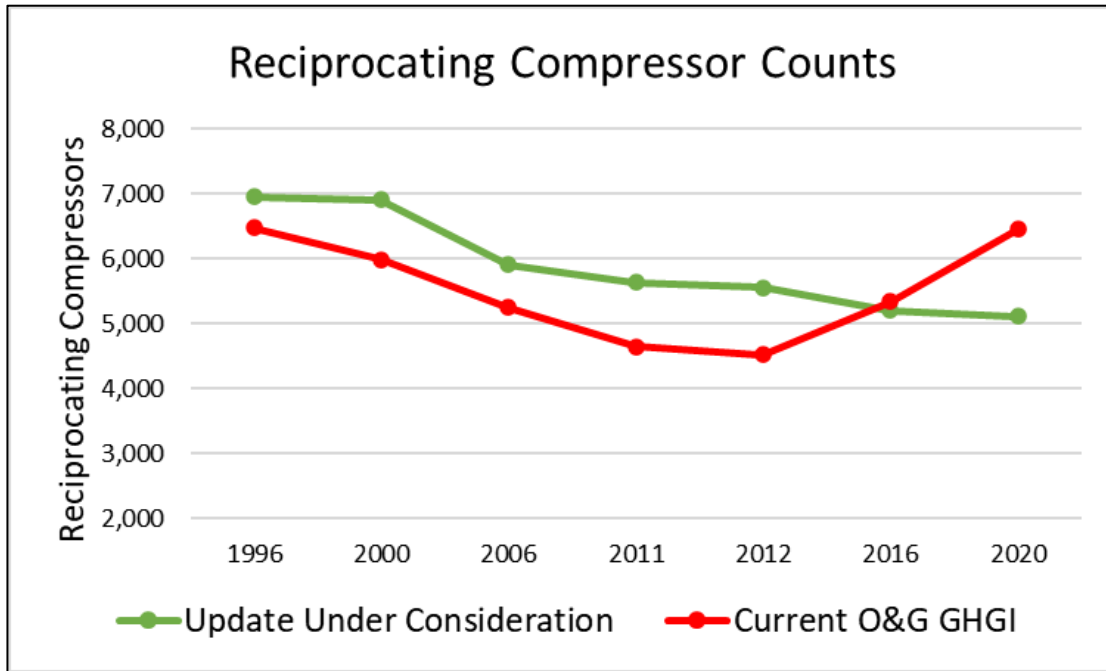
SUMMARY OF UPDATE UNDER CONSIDERATION – DATA ANALYSIS

- Analyzed FERC Form 2 data for seven years
 - Calculated year-specific activity factors
 - Transmission miles/station
 - Total compressors/station
- **Station counts:** Applied FERC miles/station to PHMSA pipeline miles
- **Compressor counts:** Applied FERC compressors/station to national station counts
- **Reciprocating and wet/dry seal centrifugal compressor counts (no update):** Applied the fraction of each compressor type from subpart W to compressor counts

SUMMARY OF UPDATE UNDER CONSIDERATION – ACTIVITY DATA



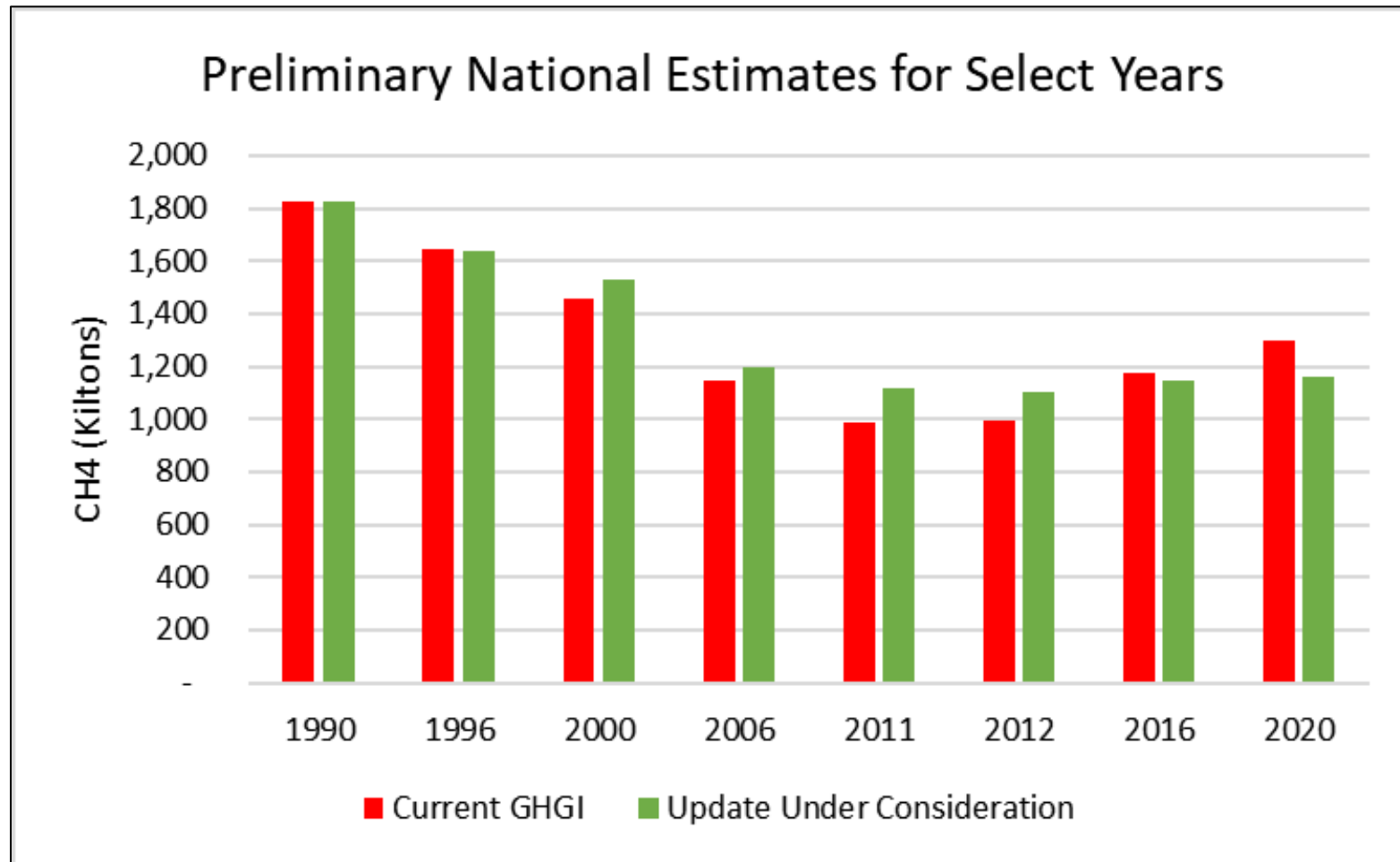
SUMMARY OF UPDATE UNDER CONSIDERATION – ACTIVITY DATA



TIME SERIES CONSIDERATIONS

- **Station counts:** Apply FERC miles/station to PHMSA miles for 1996 – 2022
 - Retain existing national station counts for 1990 – 1992 and use linear interpolation for 1993 – 1995
- **Compressor counts:** Apply FERC compressors/station for 1996 – 2022
 - Retain existing national compressor counts for 1990 – 1992 and use linear interpolation for 1993 – 1995
- **Reciprocating and centrifugal (wet and dry seal) compressor counts:** Apply the fraction of each compressor type from subpart W for 2011 – 2022
 - Retain existing compressor counts for 1990 – 1992 and use linear interpolation for 1993 – 2010

SUMMARY OF UPDATE UNDER CONSIDERATION – PRELIMINARY TRANSMISSION SEGMENT EMISSIONS



REQUESTS FOR STAKEHOLDER FEEDBACK

1. Are there additional data sources that EPA should review and consider using to update transmission station and compressor counts in the GHGI to reflect ongoing trends?
2. Are there data sources that contain information on state-level or regional (e.g., basin-level) station and compressor counts that can be used in the GHGI?
3. Are there alternative data sources or methods that EPA should consider applying to scale up station and compressor counts to generate national estimates?
4. EPA's proposed subpart W updates could change the number of transmission compression facilities reporting to the GHGRP. Should EPA consider using GHGRP data as an input to develop national transmission compressor station counts and compressor unit counts? If so, what considerations should be given to using GHGRP data in this way?

UPDATE UNDER CONSIDERATION FOR 2024 GHGI: COMPLETION AND WORKOVER EMISSIONS

CURRENT GHGI METHODOLOGY

- **Emission sources**

1. Hydraulically fractured (HF) gas well completions
2. HF gas well workovers
3. Non-HF gas well completions
4. Non-HF gas well workovers
5. HF oil well completions
6. HF oil well workovers
7. Non-HF oil well completions
8. Non-HF oil well workovers

- **Activity Data (completion and workover event counts):**

- Uses mix of Enverus, subpart W, and historical data

- **Emission Factors (EFs) and Activity Factors (AFs):**

- Develop national average factors for each activity and control group using subpart W data

Control Categories

REC vs. non-REC	Flare vs. Vent
HF Completions and Workovers	
Non-REC	Vent
Non-REC	Flare
REC	Vent
REC	Flare
Non-HF Gas Well Completions and Workovers	
n/a	Vent
n/a	Flare
Non-HF Oil Well Completions and Workovers	
n/a	Vent

CURRENT GHGI ACTIVITY DATA APPROACH

Activity Data Element	Current GHGI Approach
HF gas well completions	Enverus (for 1990 – 2010) and subpart W direct counts (for 2011 forward)
HF gas well workovers	1% of HF gas wells are worked-over annually, from analysis supporting 2012 NSPS rulemaking
Non-HF gas well completions	400 completions for all gas wells in 1992 (1996 GRI/EPA), scaled for other years
Non-HF gas well workovers	4.35% of non-HF gas wells are worked-over annually (1996 GRI/EPA)
HF oil well completions	Enverus
HF oil well workovers	1% of HF oil wells are worked-over annually, from analysis supporting 2012 NSPS rulemaking
Non-HF oil well completions	Number of oil wells drilled (EIA) minus the number of HF oil well completions (Enverus)

CURRENT GHGI CALCULATION METHODOLOGY (EXAMPLE)

HF Gas Well Completions REC with Venting

$$\text{Emissions} = EF_{\text{cat}} \times AD \times AF_{\text{cat}}$$

- EF_{cat} = national emissions per REC with venting completion event (CH₄/CO₂/N₂O)
 - AD = # national HF gas well completions
 - AF_{cat} = percent of completions that are REC with venting nationally
-
- Other completion and workover methodologies follow similar approach

SUMMARY OF UPDATES UNDER CONSIDERATION

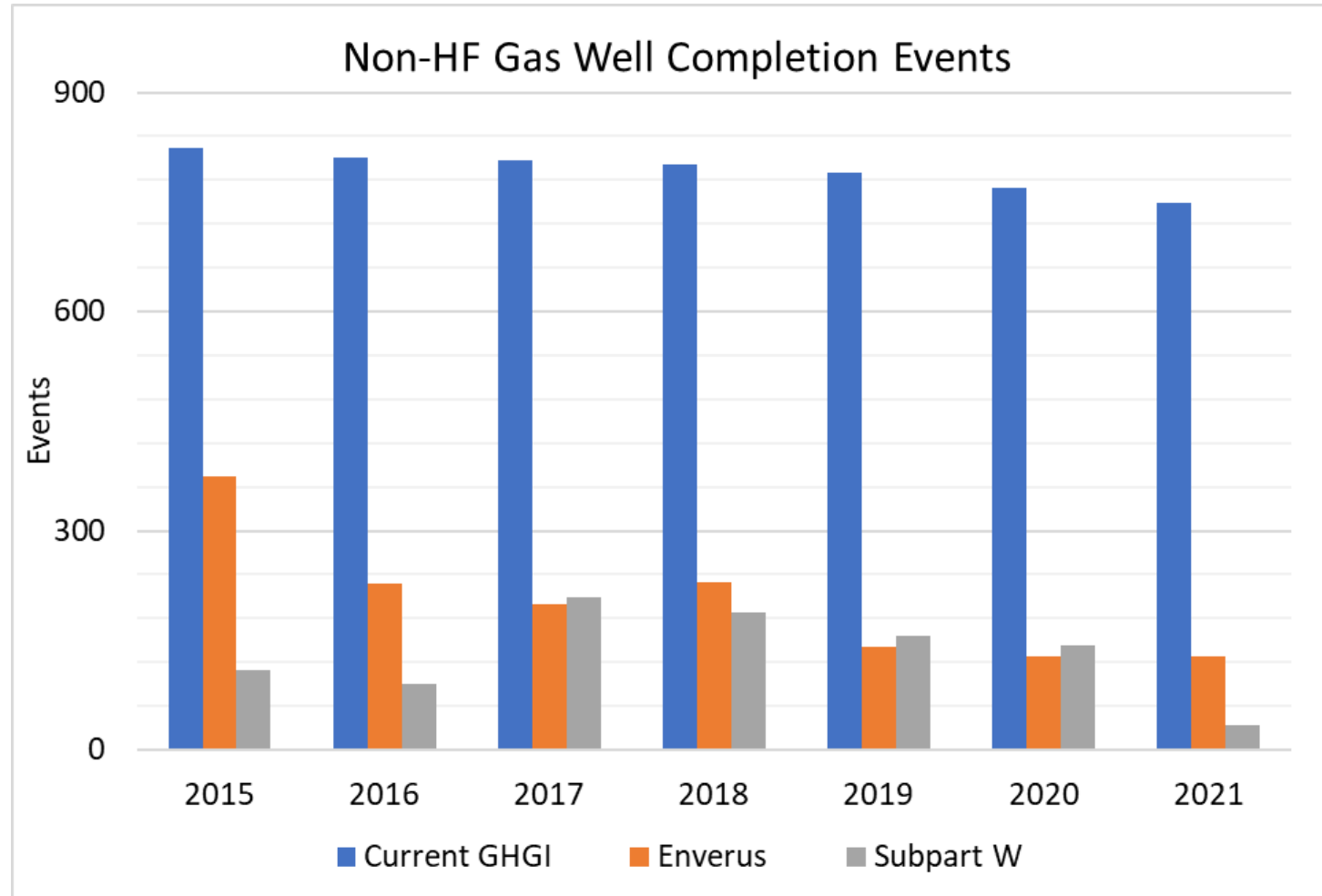
- **Data source for events:** Update activity data source for completion and workover event counts using Enverus and subpart W
- **Basin-level calculations**
 - **Event Counts:** Use updated data sources at basin-level
 - **Emission Factors (EFs) and Activity Factors (AFs):** Calculate basin-level EFs and AFs using subpart W data instead of national average EFs and AFs

DATA SOURCE UPDATE FOR COMPLETION AND WORKOVER EVENTS

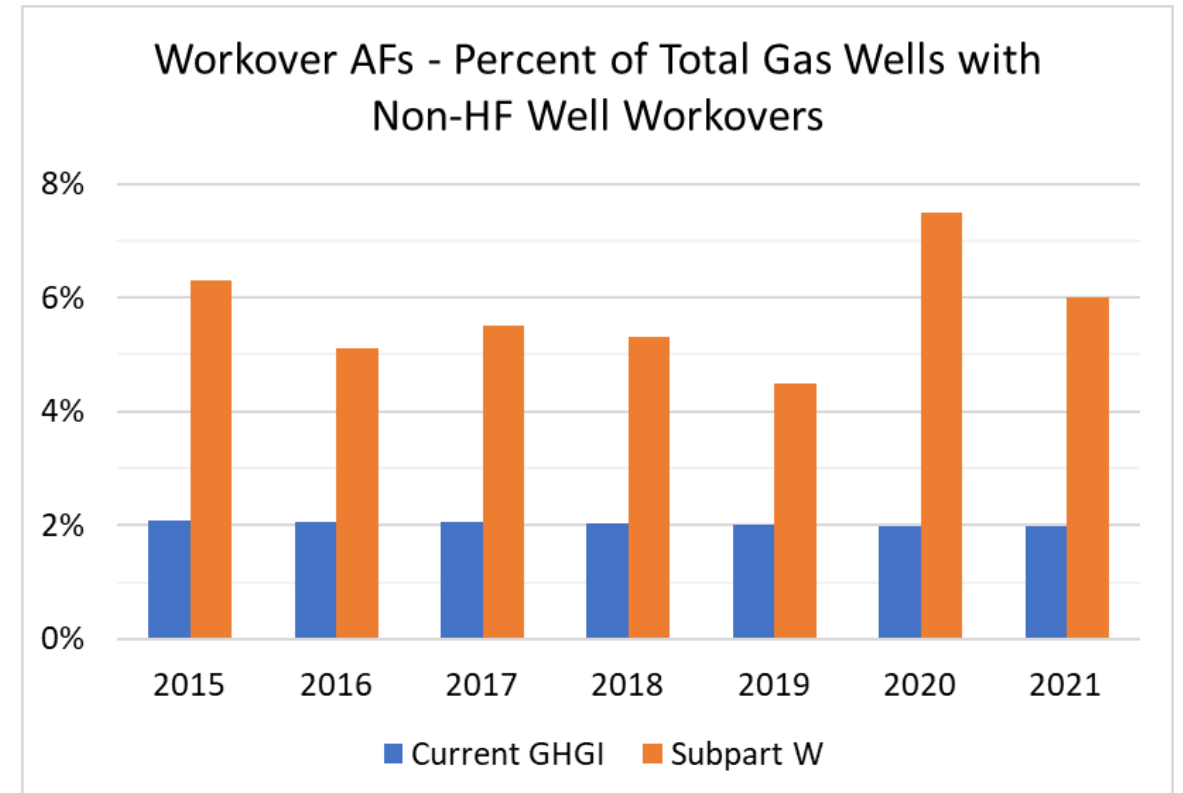
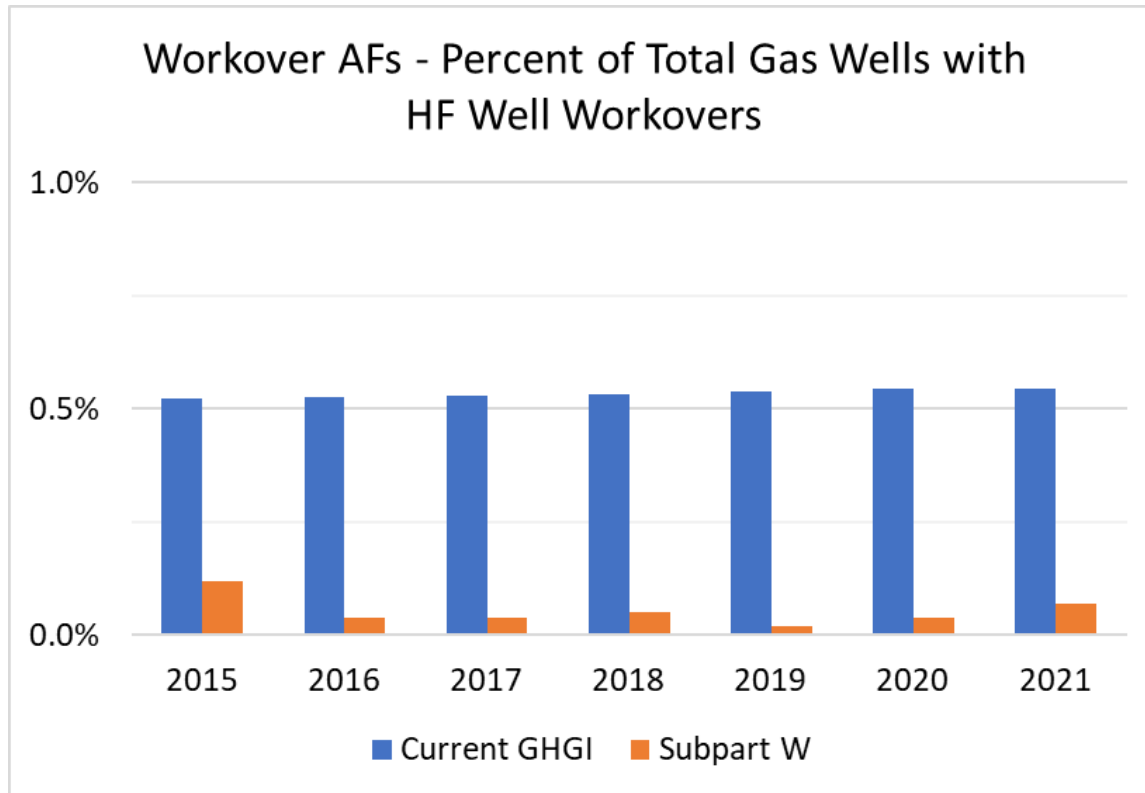
DATA SOURCE UPDATES UNDER CONSIDERATION

Activity Data Element	Current GHGI Approach	Update Under Consideration
HF gas well completions	Enverus (for 1990 – 2010) and Subpart W direct counts (for 2011 forward)	Retain current approach
HF gas well workovers	1% of HF gas wells are worked-over annually	Subpart W
Non-HF gas well completions	400 completions per year for all gas wells in 1992, scaled for other years	Enverus
Non-HF gas well workovers	4.35% of non-HF gas wells are worked-over annually	Subpart W
HF oil well completions	Enverus	Retain current approach
HF oil well workovers	1% of HF oil wells are worked-over annually	Subpart W
Non-HF oil well completions	Number of oil wells drilled (EIA) minus the number of HF oil well completions (Enverus)	Enverus

DATA SOURCE UPDATE EXAMPLE: NON-HF GAS WELL COMPLETIONS



DATA SOURCE UPDATE EXAMPLE: WORKOVER ACTIVITY FACTORS



BASIN-LEVEL: COMPLETION AND WORKOVER EVENTS

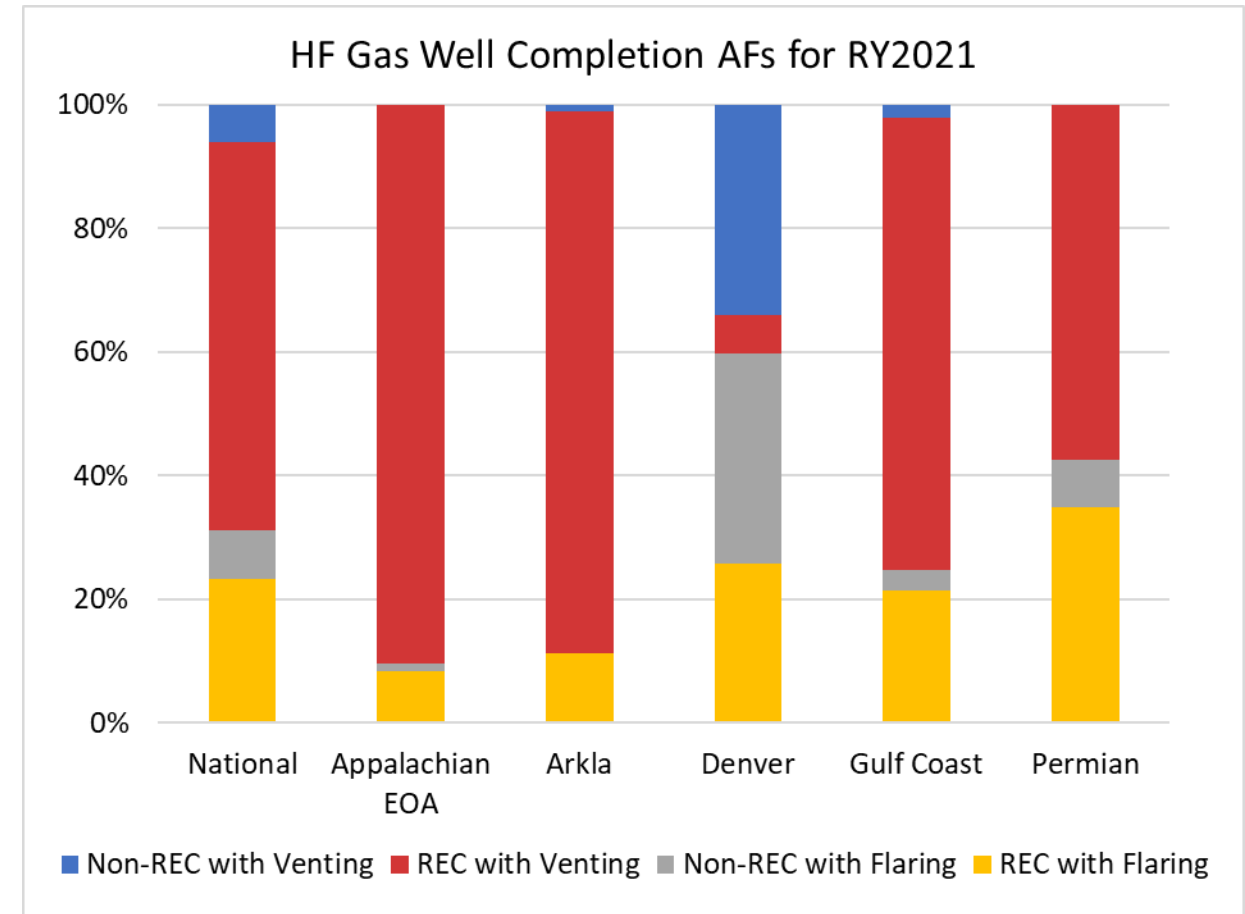
BASIN-LEVEL EVENT COUNTS

- Use Enverus and/or subpart W data to determine the number of events at the basin level for:
 - Non-HF Gas Well Completions
 - Non-HF Oil Well Completions
 - Non-HF Gas Well Workovers
 - HF Gas Well Workovers
 - HF Oil Well Workovers
 - HF Gas Well Completions
 - HF Oil Well Completions

BASIN-LEVEL: CONTROL CATEGORY AFs

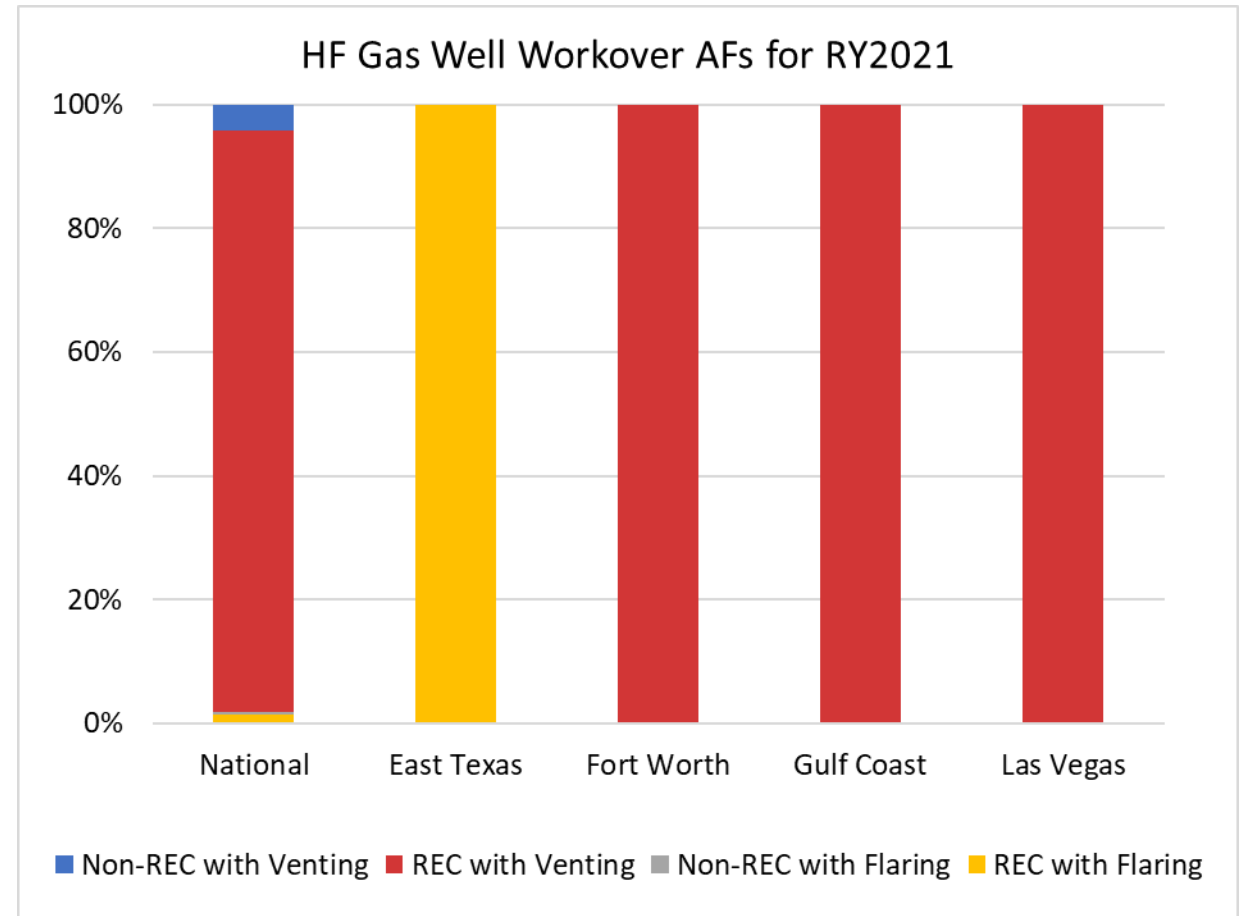
EXAMPLE: HF GAS WELL COMPLETION CONTROL CATEGORY AFS

- Activity factors apportion the completion event counts into control categories for HF gas well completions
- Update under consideration: Calculate AFS for each basin instead of a national average



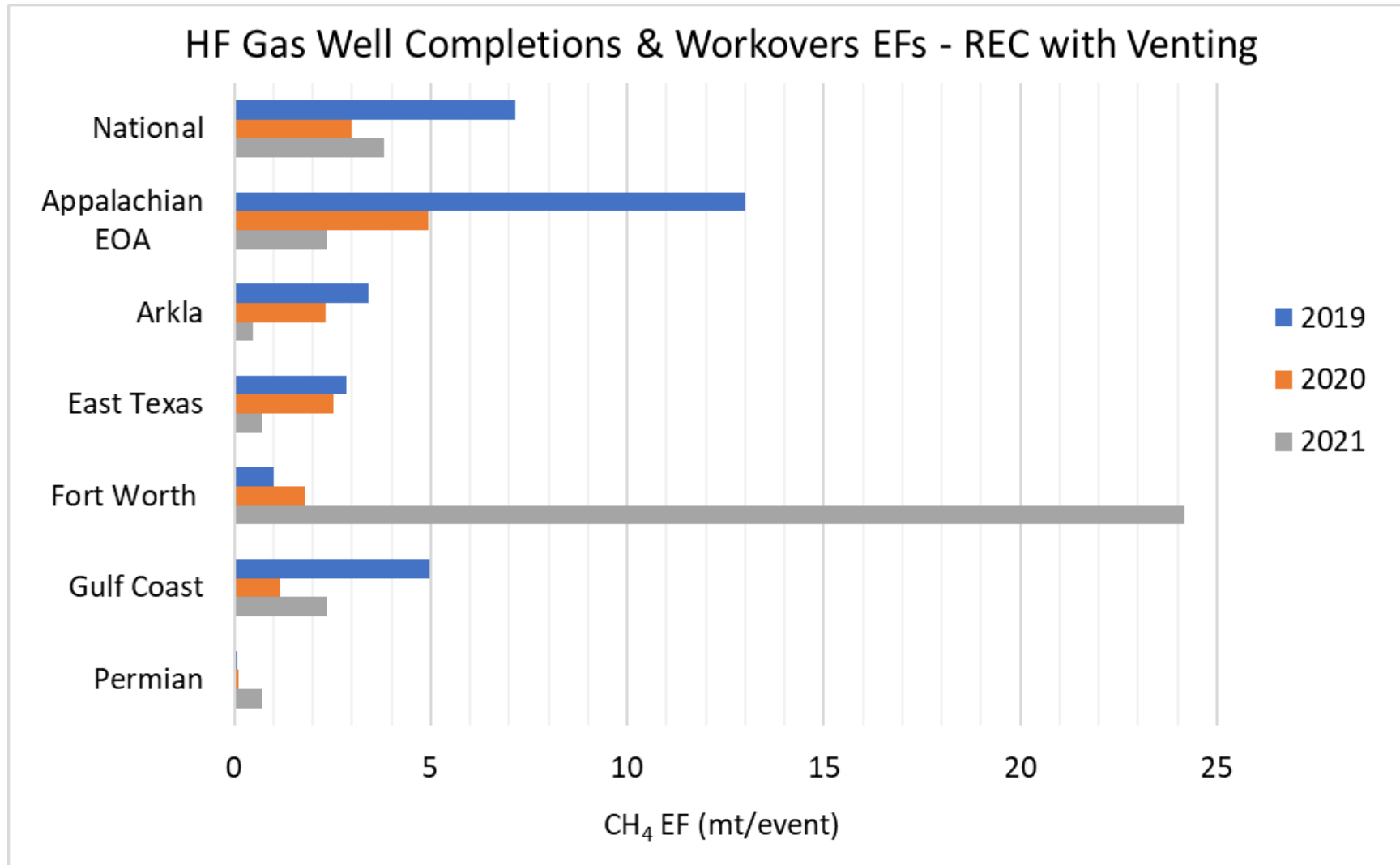
EXAMPLE: HF GAS WELL WORKOVER CONTROL CATEGORY AFS

- Activity factors apportion the workover event counts into control categories for HF gas well workovers
- Update under consideration: Calculate AFS for each basin instead of a national average

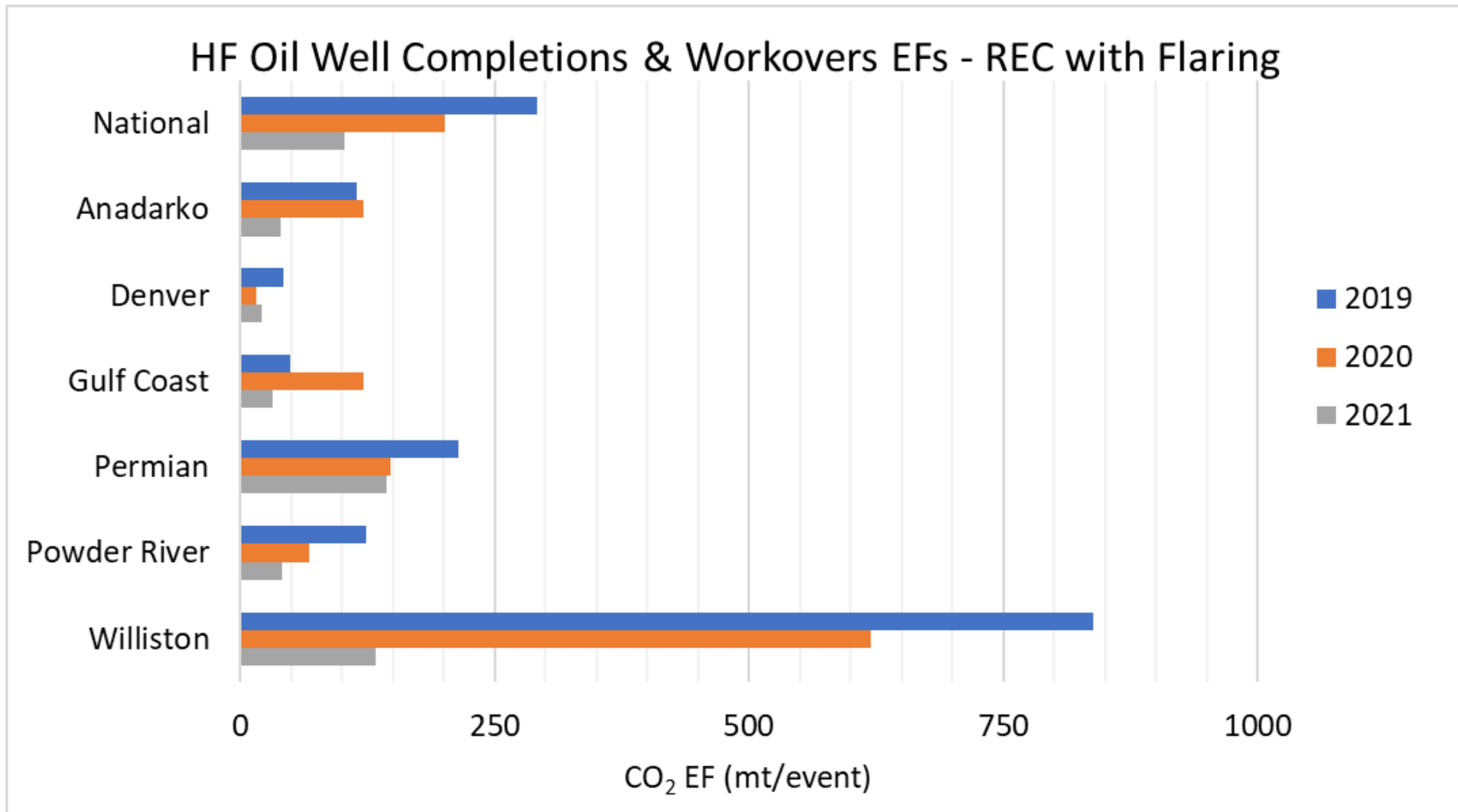


BASIN-LEVEL: EMISSION FACTORS

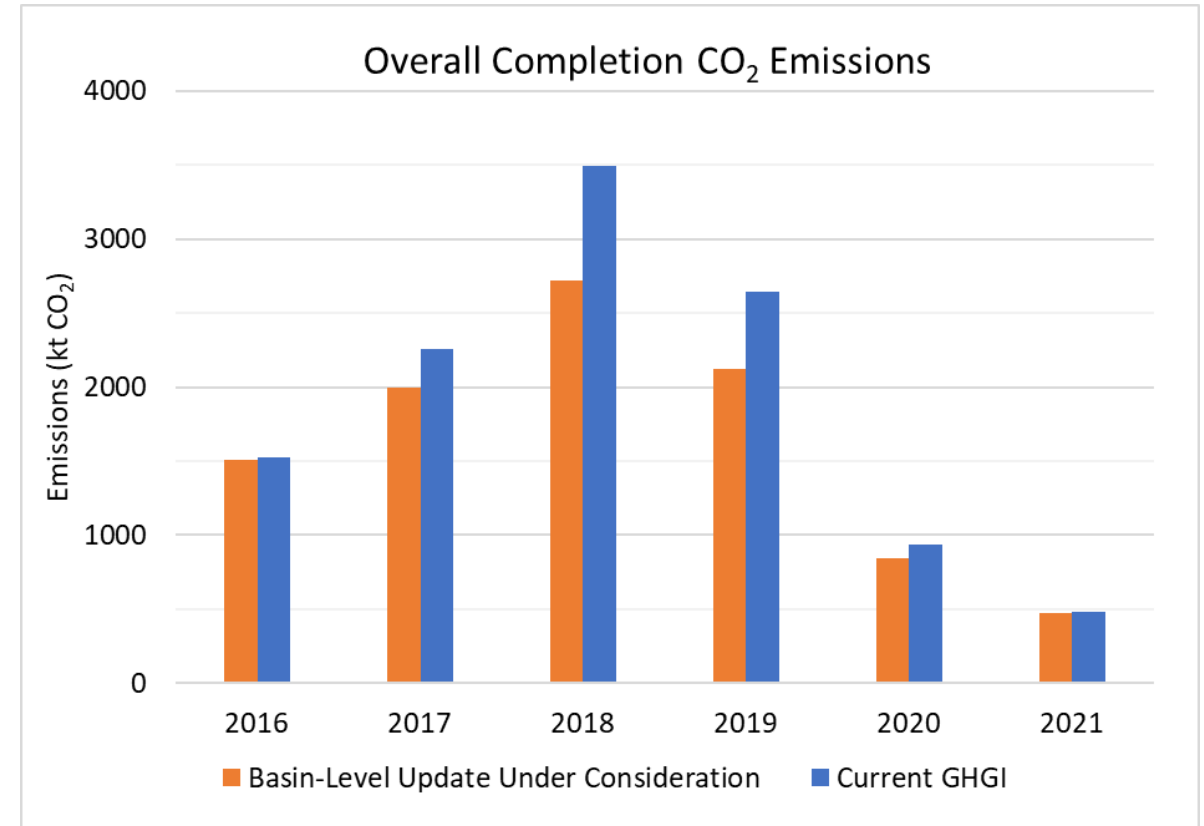
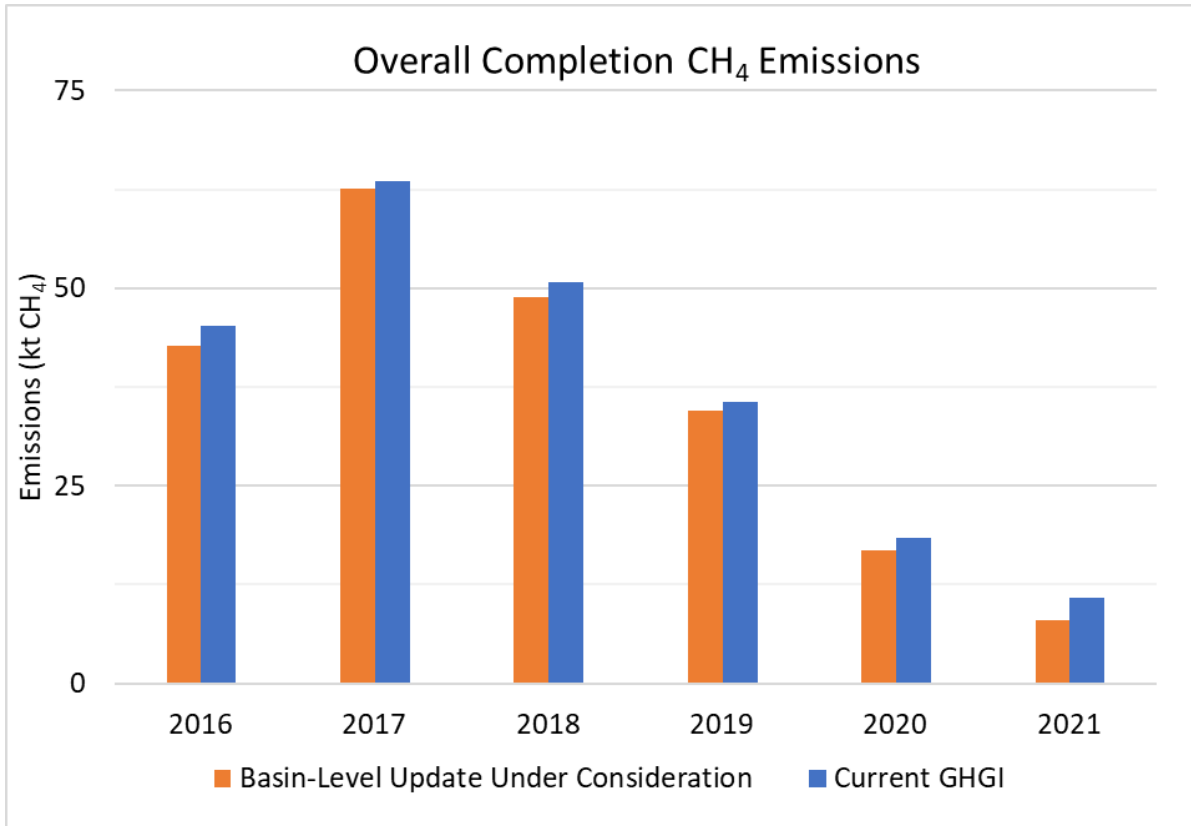
EXAMPLE: GAS WELL REC WITH VENTING EFs



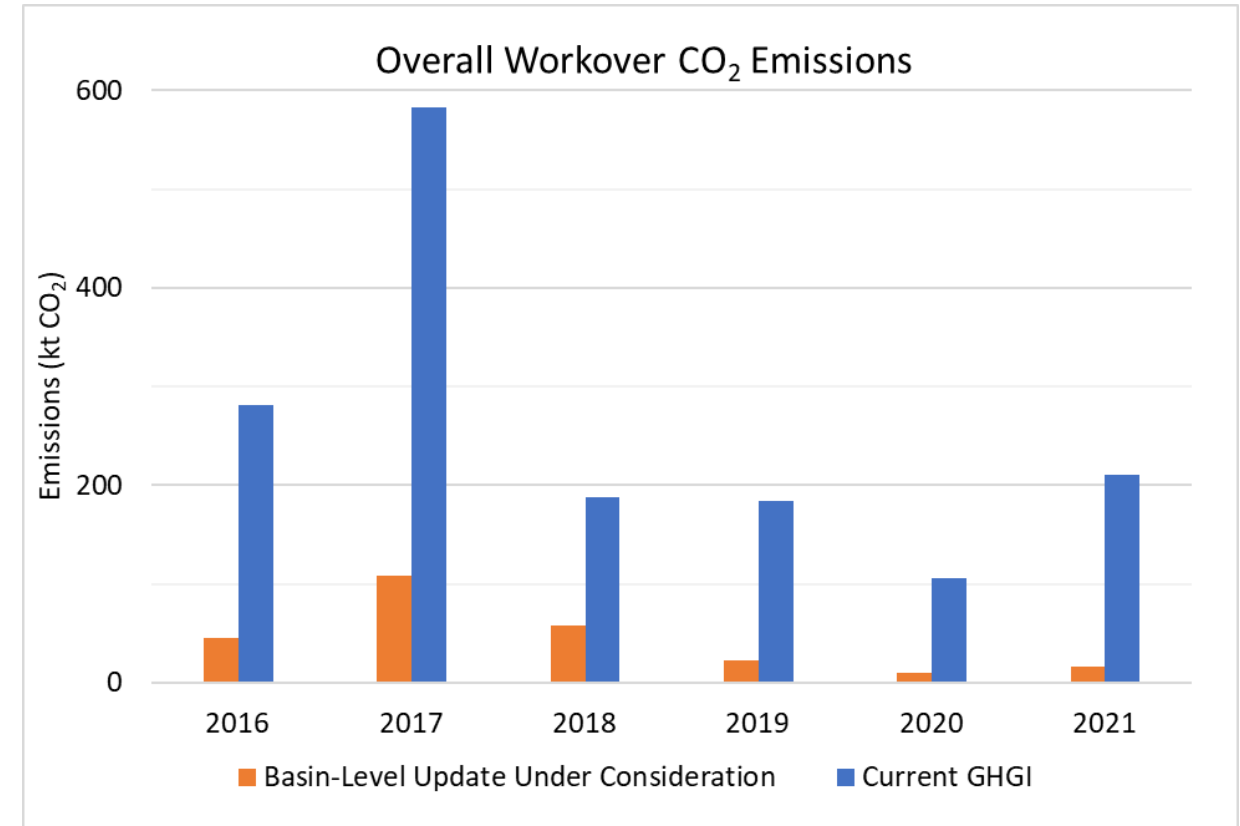
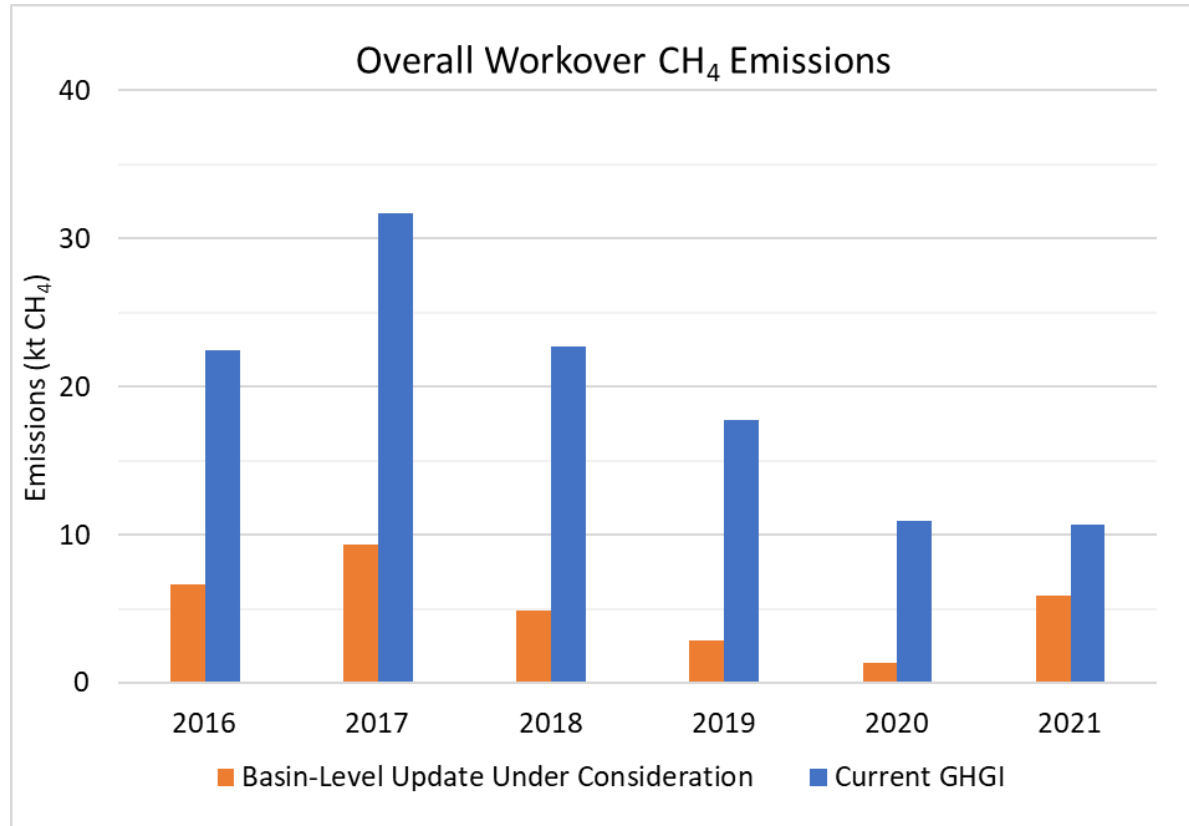
EXAMPLE: OIL WELL REC WITH FLARING EFs



PRELIMINARY EMISSION ESTIMATES (HF AND NON-HF OIL AND GAS COMPLETIONS)



PRELIMINARY EMISSION ESTIMATES (HF AND NON-HF OIL AND GAS WORKOVERS)



REQUESTS FOR STAKEHOLDER FEEDBACK

1. Are there additional data sources that EPA should review and consider using to update completion and workover event counts used in the GHGI to reflect ongoing trends?
2. For a few years, subpart W reports higher counts of non-HF gas well completions than total national counts in Enverus. For most years, in certain basins, subpart W reports higher reported counts than total counts in Enverus. What approaches should EPA consider to address these discrepancies?
3. What potential benefits and potential disadvantages should EPA consider when updating the GHGI to use an approach that incorporates additional basin-level calculations?
4. What approaches should EPA consider for basins that have subpart W data reported in certain years (e.g., RY2015-RY2017, RY2019, RY2021), but not all GHGRP years (e.g., no data in RY2018, RY2020)? For example, using a basin's data from surrounding years, applying average data (based on multiple basins) to those years, or assume the activity did not occur in that year.

UPDATE UNDER CONSIDERATION FOR 2024 GHGI: UNDERGROUND NATURAL GAS STORAGE EMISSION EVENTS

BACKGROUND AND CURRENT GHGI METHODOLOGY

- Current GHGI includes large emission events from production wells and one Underground Natural Gas Storage Facility (UNGSF) event
- EPA first included methane emissions from Aliso Canyon in the 2015 and 2016 estimates in the 2018 GHGI
- GHGI includes equipment leak emissions from storage wells; Aliso Canyon event was added to that category

DATA SOURCES REVIEWED

- EPA evaluated data from Li et al. (2022) “A national estimate of U.S. underground natural gas storage incident emissions,” analyzed event emissions from 1984-2016
- Li et al. used data from two supporting studies
 - Evans and Chadwick, 2009: qualitative review of events from 1953-2006
 - Folga, 2016: includes PHMSA data for the years 1984-2016
- PHMSA data evaluated in the study was analyzed in three subgroups based on the data reported to PHMSA
 - 1984-2001: Gas release volume/gas cost unavailable
 - 2002-2009: Cost of gas lost
 - 2010-2016: Gas release volume

ANALYSIS OF AVAILABLE DATA

- Focused on storage well events in Li et al.
 - 10 storage well events out of the 69 events evaluated by Li et al.
 - 5 well blowout events
 - Other 5 well events were periods of shorter gas release due to well equipment damage
- Li et al. did not take into consideration combustion of methane for events where gas ignited or exploded
 - Gas ignition or explosion for 4 out of 10 storage well events
 - For this update under consideration, EPA applied a combustion efficiency of 60%
 - Maasackers et al. (2022) used 60% as a lower estimate in ranges of combustion efficiencies (for flares)

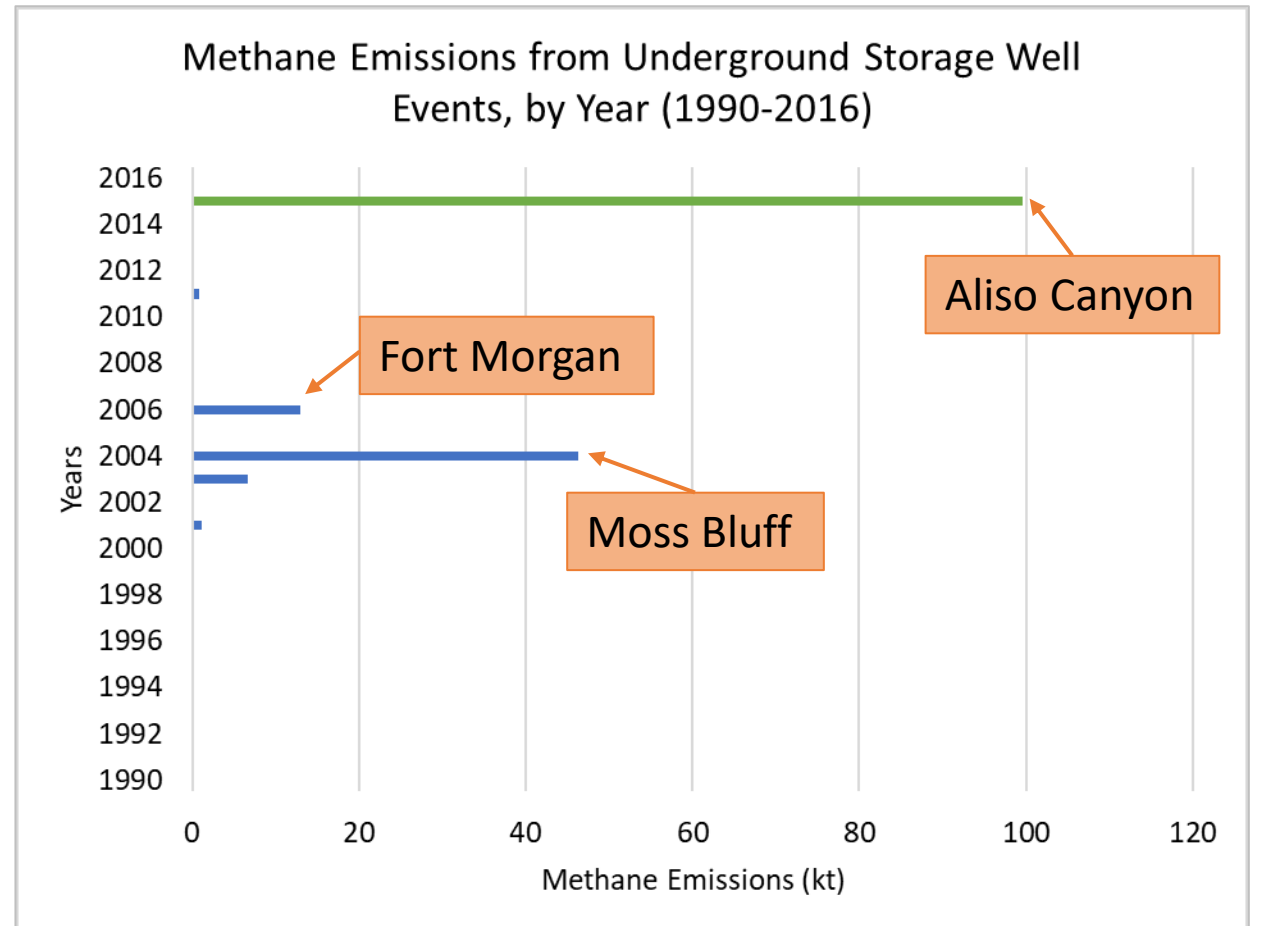
ANALYSIS OF AVAILABLE DATA

Field Name	State	Year	Leak Size (mcf)	CH ₄ Release (mt)	CH ₄ Emissions (mt)	CO ₂ Combustion Emissions (mt)
Aliso Canyon	CA	2015 – 2016	5,000,000	99,638	99,638	-
Moss Bluff Storage	TX	2004	6,000,000	115,560	46,224	203,310
Fort Morgan	CO	2006	675,000	13,001	13,001	-
Magnolia Gas Storage	LA	2003	350,000	6,741	6,741	-
Yaggy	KS	2001	143,000	2,754	1,102	4,846
Edmond	OK	2011	42,919	827	827	-
Cunningham	KS	2002	10,185	196	196	-
Stuart Storage	OK	1998	8,500	164	164	-
Redfield	IA	2010	1,970	38	15	69
Hawesville N W	KY	1992	14	0.3	0.1	0.5
Total			12,231,588	238,918	167,907	208,226

SUMMARY OF UPDATE UNDER CONSIDERATION – PRELIMINARY EMISSIONS BY YEAR

10 Inventory Years with an
Underground Storage Well event:

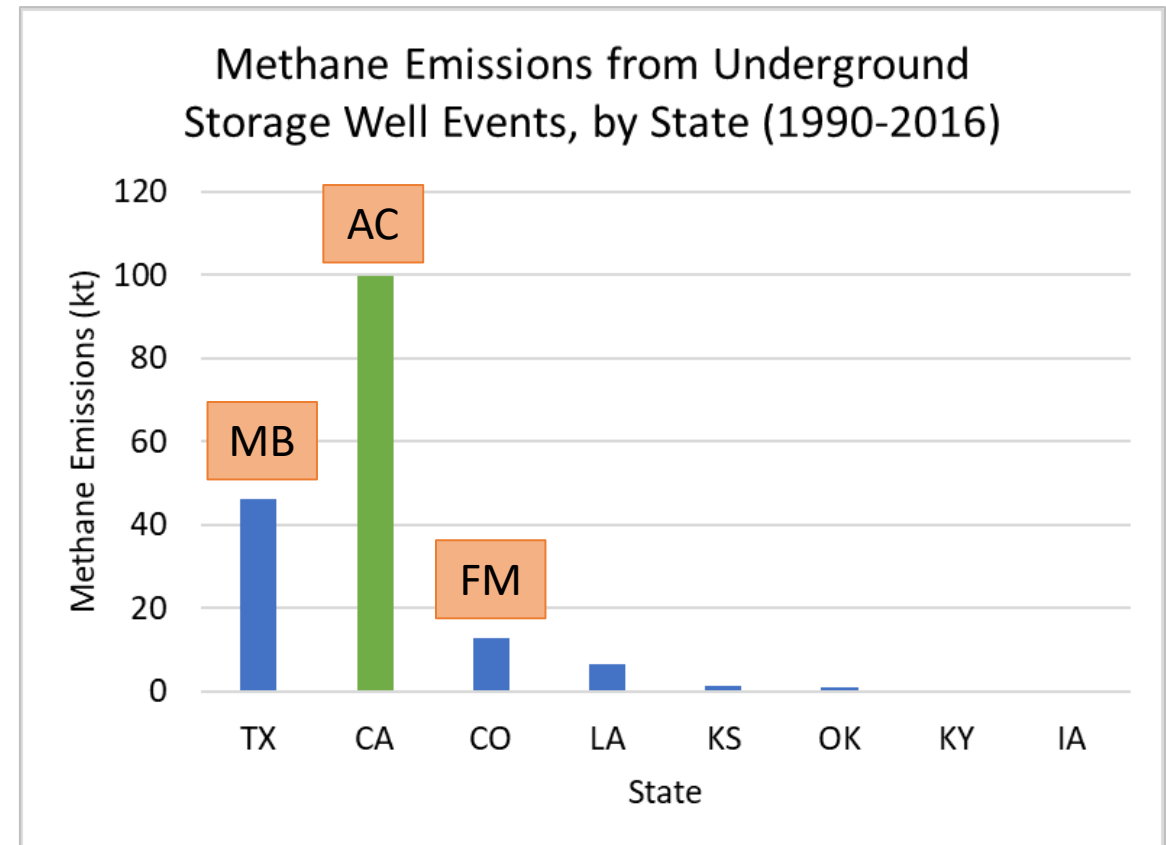
- 1992, 1998, 2001, 2002, 2003, 2004, 2006, 2010, 2011, 2015



SUMMARY OF UPDATE UNDER CONSIDERATION – PRELIMINARY EMISSIONS BY STATE

States with Underground Storage
Well events from 1990-2016:

- TX: 1
- CA: 1
- CO: 1
- LA: 1
- KS: 2
- OK: 2
- KY: 1
- IA: 1



REQUESTS FOR STAKEHOLDER FEEDBACK

1. EPA seeks feedback on including emissions resulting from underground natural gas storage events to the time series.
2. EPA seeks feedback on the appropriate combustion efficiency to apply.
3. EPA seeks feedback on whether events other than storage well events from Li et al. should be considered.
4. EPA requests feedback for how to incorporate large leak events, as included in proposed revisions to subpart W, into the GHGI.

WRAP-UP

NEXT STEPS

- Memos on updates under consideration to be available soon at <https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2022-inventory>
- Please send feedback to ghginventory@epa.gov
- Public review draft available in early 2024