

Approaches to Greenhouse Gas Emissions Estimation for Oil and Natural Gas Industry

Extended Abstract #: 008

Karin Ritter

American Petroleum Institute, 1220 L Street, NW, Washington DC 20005

Gordon Reid Smith

BP America Inc., 501 Westlake Park Blvd, Houston, TX 77079

Terri Shires

URS Corporation, 9400 Amberglen Blvd., Austin, TX 78729

Miriam Lev-On

The LEVON Group, LLC, 236 Marjorie Avenue, Thousand Oaks, CA 91320

INTRODUCTION

Emerging mandatory greenhouse gas (GHG) emissions reporting programs and voluntary initiatives in the United States are leading to potential inconsistencies of reported GHG emissions. The diversity of protocols and methods being promulgated by states, regional initiatives and the national government poses a particular challenge for companies with widely varying operational complexity and spatial diversity, such as in the oil and natural gas industry.

The American Petroleum Institute (API) and its member companies recognized these challenges and the need for accurate, reliable and transparent characterization of GHG emissions, over a decade ago. Since 2000, a series of technical documents and tools that promote consistent and accurate GHG emission quantification for GHG inventories and emission reduction projects have been developed and widely disseminated for broad use and adoption. These documents have received worldwide recognition for their thoroughness and for providing technically sound guidance.

This paper compares and contrasts GHG emission calculation methods for U.S. regulatory programs, with an emphasis on oil and gas production operations. The analysis focuses on a comparison of emission quantification methodologies from *API's Compendium of GHG Emissions Estimation Methodologies for the Oil and Gas Industry*¹, the U.S. Environmental Protection Agency GHG Reporting Program (GHGRP), the California Air Resources Board (CARB), and the Western Climate Initiative (WCI).

OVERVIEW OF REPORTING PROGRAMS

California was the first state to require the reporting of GHG emissions, dating back to December 2007 when the CARB adopted a regulation requiring the largest industrial sources to report and verify their GHG emissions. The reporting regulation provides a foundation for California's emerging Cap and Trade program as part of the state's commitment to reduce GHG emissions to 1990 levels by 2020 - a reduction of approximately 30 percent.

The WCI adopted its requirements for mandatory reporting in July 2009. Seven states are partners in the program (Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington), with another six states participating as observers (Alaska, Colorado, Idaho, Kansas, Nevada, and Wyoming). U.S. partner states are expected to adopt an incorporation-by-reference rule to implement the WCI Essential Requirements for Mandatory Reporting². With the promulgation of the national GHGRP by the U.S. EPA, the WCI made a special effort to minimize reporting burden in the U.S. and harmonize reporting requirements³ with those provided by the U.S. EPA, with the provision that more stringent accounting and measurement methods may be mandated to meet the data quality needs of WCI's Cap and Trade program.

The current status of GHG reporting rules for each of the WCI partner states is summarized briefly below:

Arizona - indicated that it will continue to be a member of the WCI. However, Arizona will not implement the GHG Cap and Trade proposal during this economic downturn.

California – requires reporting of GHGs by major sources per the 2006 California Global Warming Solutions Act⁴. Reporting began in 2009. More details on California's GHG reporting requirements are addressed below.

Montana - broad-based legislation addressing climate change has not emerged. The 2011 Montana Legislative session did not pass regulations requiring the reporting of GHG emissions.

New Mexico - adopted a GHG reporting rule in 2007, requiring reporting of CO₂ emissions, beginning in 2008, for Title V sources. The original rule requirements were repealed in January 2011 and replaced with requirements⁵ that are aligned with EPA's GHGRP and the WCI.

Oregon - adopted GHG reporting rules in 2008 and revised the requirements⁶ in 2010 to align them with the EPA GHGRP and to expand them to facilities emitting more than 2,500 tonnes or CO₂ equivalent (CO₂e) emissions with specific requirements for natural gas suppliers.

Utah - the Air Quality Board recently recommended against developing a state GHG emission inventory and GHG reduction plan unless there is specific legislative authority.

Washington - adopted GHG reporting requirements⁷ on December 1, 2010. The rule became effective January 1, 2011, and the reporting requirements begin in January 1, 2012. Washington's regulations require reporting for petroleum refineries as well as upstream oil and gas operations. Requirements generally follow EPA's GHGRP.

On the national level, the U.S. EPA adopted the first wave of mandatory reporting rules⁸ under the GHGRP in October 2009. Notably, the reporting requirements for oil and natural gas systems⁹ were finalized in November 2010 and expanded to include onshore petroleum and gas production activities.

A key difference between EPA's GHGRP and the CARB or WCI programs is that the Federal program is solely a reporting program, while the CARB and WCI programs aim to use the reported data to regulate GHG emissions through a Cap and Trade program.

For companies operating in the state of California, and/or WCI participating states, the requirement to report emissions under multiple programs presents a problem of reporting potentially duplicative and conflicting information. In order to minimize the impact of different reporting programs WCI adopted their principles of harmonizing reporting programs, and CARB amended its program to more closely align with the EPA requirements, with a few exceptions. Table 1 outlines key differences among the reporting programs.

Table 1. General Programs Comparison.

Reporting Requirement	EPA GHGRP	CARB¹⁰	WCI
Threshold	≤ 25,000 tonnes CO ₂ e/yr starting in 2010	≤ 25,000 tonnes CO ₂ e/yr starting in 2009 Proposed ≤ 10,000 tonnes CO ₂ e/yr starting in 2012	≤ 10,000 tonnes CO ₂ e/yr starting in 2010
Reporting due date	Annually on March 31 st . Extended to September 30, 2011 for the initial reporting year and to September 28, 2012 for some Subpart including Oil and Natural Gas Systems.	Annually on April 1 st or June 1 st depending on the industrial sector	Annually on April 1 st but may vary with state specific requirements
Gases Reported	CO ₂ , methane (CH ₄), nitrous oxide (N ₂ O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF ₆), and other fluorinated compounds (e.g., HFEs).	Vary by sector. For Oil & Gas operations reporting of CO ₂ , CH ₄ , and N ₂ O for major combustors only.	Vary by sector and by state requirements. For all combustion devices, requires reporting of CO ₂ , CH ₄ , and N ₂ O
Validation and Verification	Internal validation by Designated Representatives; EPA will conduct data checks and audits for verification	Requires 3 rd Party Verification	Requires 3 rd Party Verification
Scope of Upstream Oil and Gas Operations	Excludes gathering lines and natural gas booster stations. Includes portable combustion sources only for production and distribution. Includes flares only for production.	Includes natural gas booster stations. Includes flares for all upstream operations.	Currently does not address upstream oil & gas sources. WCI provided comments to EPA during the development of Subpart W rules.

The API Compendium, in contrast to the EPA, CARB, and WCI programs, is not a reporting or emissions inventory program. The API Compendium was developed to support consistent emission calculation methods for voluntary GHG reporting for oil and natural gas industry operations worldwide. The API Compendium provides an expansive collection of relevant emission factors and estimation methodologies for GHG emissions covering the full range of industry operations – from exploration and production through refining, to the marketing and distribution of products. It is not the intent of the API Compendium to dictate specific methods, but rather to provide guidance for optional quantification techniques based on considerations of materiality, data availability, and data accuracy needs.

COMPARISON OF GHG EMISSION ESTIMATION METHODS

Combustion Emissions

Combustion emissions are the largest contributor to GHG emissions from oil and natural gas operations, accounting for approximately 59% of total CO₂e emissions from all oil and natural gas industry operations.¹ Table 2 compares the emission estimation approaches used in the API Compendium to those required by the EPA, CARB, and WCI programs for combustion emissions.

Table 2. Comparison of combustion emission estimation methods.

EPA GHGRP	API Compendium	CARB	WCI
CO₂ Emissions: Tier 1 (Eqs. C-1, C-1a, and C-1b) includes: <ul style="list-style-type: none"> ▪ Fuel use records ▪ Default HHV ▪ Default emission factor (EF) 	Optional Methods: <ul style="list-style-type: none"> ▪ Fuel use combined with default EFs based on fuel consumption or fuel energy input ▪ Fuel use combined with manufacturer EFs ▪ Engineering calculations/ estimates 	Fuel use combined with default EFs based on fuel consumption rate or fuel energy input	EPA Tier 1 approach may only be used at a facility not subject to verification
CO₂ Emissions: Tier 2 (Eqs. C-2a, C-2b) includes: <ul style="list-style-type: none"> ▪ Fuel Usage (Monthly) ▪ Fuel Analysis (HHV: frequency varies by fuel) ▪ Default EF 	Monitoring over a range of conditions and deriving emission factors	Same as EPA approach, though more frequent HHV determinations for natural gas	EPA approach may be used for a unit combusting pipeline quality natural gas or distillate fuel oil at a facility not subject to verification
CO₂ Emissions: Tier 3 (Eqs. C-3, C-4, C-5) includes: <ul style="list-style-type: none"> ▪ Fuel use (metered directly) ▪ Fuel Analysis (carbon content: frequency varies by fuel) 		Same as EPA approach, though more frequent analyses	EPA approach must be used for unit with maximum heat rate capacity > 250 MMBtu/hr or located at a facility subject to verification.
CO₂ Emissions: Tier 4 (Eqs. C-6 and C-7): Hourly Continuous Emissions Monitoring System (CEMS) Measurement	Periodic or continuous monitoring of emissions or parameters for calculating emissions	Consistent with EPA requirements	Same requirements as EPA
CH₄ and N₂O Emissions: Applies default emission factor to quantity of fuel use (in units of energy content)	Emission factors are provided for different combustion equipment and fuel types	Consistent with EPA approach, though measured HHV must be used if available. A facility may apply approved source-specific EFs	Consistent with EPA approach. A facility may apply approved source-specific EFs

¹ Based on 2009 data of CH₄ emissions from natural gas systems and petroleum systems (http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm), 2009 data on CO₂ emissions from refinery operations, and natural gas use associated with production, processing, and pipeline operations (http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm). This estimate does not include CO₂ emissions resulting from consumer use of petroleum products and natural gas.

As shown in Table 2, the API Compendium and the regulatory reporting programs are consistent in providing a range of emission estimation methods, from the application of simple emission factors to direct measurements. A notable difference in the regulatory programs is the more restrictive flow measurements and composition determination requirements under the CARB and WCI programs, as a result of their intended use of the data for Cap and Trade programs.

Vented and Fugitive Emissions

Methane emissions from oil and natural gas operations contribute approximately 41% of GHG emissions on a CO₂e basis. These emissions result almost entirely from vented and fugitive emission sources. The estimation methods for these source types are generally specific to the type of emission source, and can vary based on operational practices and process specific conditions. Table 3 compares the emission estimation methods for a select number of vented and fugitive sources.

Table 3. Comparison of select vented and fugitive emission estimation methods.

Source Type	EPA GHGRP	API Compendium	CARB
Pneumatic device venting	98.233(a) applies count of device (by high bleed, low bleed, or intermittent bleed)	Options: <ul style="list-style-type: none"> ▪ Published EFs ▪ Manufacturer's data ▪ Engineering estimate ▪ Measurement 	Requires metering high bleed pneumatic devices starting in 2015.
Pneumatic pump venting	98.233(c) applies a default emission factor to the overall count of pneumatic pumps.	Options: <ul style="list-style-type: none"> ▪ Published EFs ▪ Manufacturer's data ▪ Engineering estimate from pump curves ▪ Measurement 	Includes pneumatic pump vents in natural gas transmission and storage
Acid gas removal vents	Method 1: CEMS Method 2: CO ₂ content and metered volume Method 3: Inlet or outlet flow and CO ₂ content Method 4: modeling	Options: <ul style="list-style-type: none"> ▪ Published EFs ▪ Material balance ▪ Process simulation / modeling ▪ Test data or measurements 	Modified EPA's Method 2 equation. Excludes EPA Method 4.
Dehydrators	Method 1: modeling Method 2: default emission factor Material balance approach for desiccant dehydrators	Options: <ul style="list-style-type: none"> ▪ Published EFs ▪ Process simulation / modeling ▪ Test data Material balance approach for desiccant dehydrators	Excludes use of EPA Method 2. Modified calculation for desiccant dehydrators.
Production storage tanks	Method 1: modeling Method 2: sample separator oil composition and pressure Method 3: Assume all CH ₄ and CO ₂ from oil and gas compositions are emitted. Method 4: Assume all CH ₄ and CO ₂ in oil phase is emitted. Method 5: Apply EF	Options: <ul style="list-style-type: none"> ▪ Published EFs or simple correlation ▪ Correlation equation ▪ Process simulation / modeling ▪ Measurement 	Allows the use of EPA Method 1 for production ≤ 10 bbls/day. Allows the use of EPA Method 2 for production > 10 bbls/day

Source Type	EPA GHGRP	API Compendium	CARB
Compressors (non-combustion emission sources)	Default EFs for production operations. Measurements required for other sectors.	Options: <ul style="list-style-type: none"> ▪ Published EFs ▪ Engineering calculations (for vented sources) ▪ Measurement 	Measurements applied to compressors \geq 250 hp. EF approach for compressors $<$ 250 hp
Fugitive Emissions	Subpart W – 98.233(r) applies average component counts per type of equipment and default EFs	Options: <ul style="list-style-type: none"> ▪ Published facility level EFs ▪ Published equipment level emission factors 	References EPA method and factors
	Subpart W – 98.233(q) applies leak-based EFs to leaking components determined from survey	Options: <ul style="list-style-type: none"> ▪ Published source-specific EFs ▪ Engineering calculations ▪ Monitoring over a range of conditions and deriving emission factors (e.g., extrapolating to the population from a subset) 	References EPA method and factors

The WCI program does not yet require reporting of emissions from vented and fugitive emission sources. It is expected that WCI will develop reporting requirements for these emission sources in a future program update, likely aligning their requirements with those of CARB. The CARB estimation methods are fairly similar to those of the EPA, although CARB is citing the EPA GHGRP program as a reference for its methodologies,

SUMMARY

The oil and natural gas industry has been active in GHG reporting for over a decade. The API Compendium document has provided oil and natural gas companies with robust guidelines for developing voluntary GHG inventories. The methods provided in the API Compendium are generally consistent with the methods required by mandatory reporting programs in the U.S.

Both the CARB and WCI GHG reporting programs have been revised recently to better align them with the reporting requirements under EPA’s GHGRP. This will benefit companies that have to report under more than one regulatory program. A notable difference, though, are the more restrictive requirements imposed by CARB and WCI, where these programs are aimed at supporting the Cap and Trade of GHG emissions.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the API member companies and their representatives on the work group who have contributed valuable time and resources over the past ten years. We are particularly indebted to the companies that facilitated the continued enhancement of the API Compendium and those that have supported review and comment on the U.S. regulatory initiatives.

REFERENCES

1. API. "Compendium of GHG Emissions Methodologies for the Oil & Gas Industry", Version 3.0, American Petroleum Institute, Washington DC, August 2009.
http://www.api.org/ehs/climate/new/upload/2009_GHG_COMPENDIUM.pdf
2. WCI, Reporting Committee Documents, "Final Essential Requirements for Mandatory Reporting", July 15, 2009;
<http://www.westernclimateinitiative.org/component/remository/Reporting-Committee-Documents/Final-Essential-Requirements-for-Mandatory-Reporting/>
3. WCI, Reporting Committee Documents, "Harmonization of Essential Requirements for Mandatory Reporting in U.S. Jurisdictions with EPA Mandatory Reporting Rule", Nov 15 2010;
<http://www.westernclimateinitiative.org/document-archives/Reporting-Committee-Documents/Harmonization-of-Essential-Requirements-for-Mandatory-Reporting-in-U.S.-Jurisdictions-with-EPA-Mandatory-Reporting-Rule/>
4. California Assembly Bill 32: Global Warming Solutions Action, 2006.
<http://www.arb.ca.gov/cc/ab32/ab32.htm>
5. New Mexico Environmental Improvement Board, Title 20 Environmental Protection, Chapter 2 Air Quality (Statewide), Part 300 Reporting of Greenhouse Gas Emissions, November 10, 2010. <http://www.nmenv.state.nm.us/aqb/ghg/Guideto20.2.300NMAC.htm>
6. Oregon Department of Environmental Quality, Greenhouse Gas Reporting, Accessed July 20, 2011, <http://www.deq.state.or.us/aq/climate/reporting.htm>
7. Washington, Department of Ecology, Chapter 173-441 WAC - Reporting of Emission of Greenhouse Gases,
http://www.ecy.wa.gov/programs/air/globalwarm_RegHaze/GreenHouseGasreporting_rule.html
8. U.S. EPA, 40 CFR Parts 86, 87, 89 et al., Mandatory Reporting of Greenhouse Gases; Final Rule, 74 FR 56259, October 30, 2009
<http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf>
9. U.S. EPA, 40 CFR Part 98, Mandatory Reporting of Greenhouse Gases: Petroleum and Natural Gas Systems; Final Rule 75 FR 74458, November 30, 2010;
<http://edocket.access.gpo.gov/2010/pdf/2010-28655.pdf>
10. California Air Resources Board, Proposed Amendments to ARB Mandatory Reporting Regulation, Discussion Draft, July 7, 2011,
http://www.arb.ca.gov/cc/reporting/ghg-rep/mrr_discussion_draft.pdf