Consistency in Greenhouse Gas Emissions Estimation for Oil and Gas Industry Operations – A Non-Trivial Pursuit

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ABSTRACT

Oil and gas industry operations span the globe, encountering unique operational and business climates in a variety of regions. This reality presents many challenges for companies that are characterizing their greenhouse gas (GHG) emissions and developing GHG management strategies for diverse multinational facilities. For these companies, the consistency, reliability, and credibility of the methodology to derive GHG emission estimates are especially vital.

Recognizing this need, the American Petroleum Institute (API) formed a working group to compile recognized "best practices" for emissions estimation methodologies applicable to oil and natural gas industry operations. The resulting *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry* was first distributed in April 2001. Its initial release as a "road test" or Pilot Version document was geared toward testing its application to project, facility, or corporate level greenhouse gas emission inventories. Since its release, comments have been received through a number of mechanisms.

This paper presents findings from the pilot phase distribution of the API Compendium, including lessons learned from oil and natural gas companies that have integrated the Compendium into their corporate GHG programs. Results from outreach efforts and special studies undertaken to compare the API Compendium with other commonly used protocols are provided. Ongoing efforts by API to ensure global industry consistency and comparability in estimation techniques are also discussed.

INTRODUCTION

Estimating and reporting greenhouse gas (GHG) emissions is extremely complex for a highly integrated industry such as the oil and natural gas industry with its wide diversity of business structures under a corporate umbrella. With increased attention focused on the potential value – and risk – associated with GHG emissions, there is a need for consistent, standardized methodologies for

estimating GHG emissions. This will allow for meaningful emissions comparisons and assure that emission credits are assessed using the same "carbon currency" basis.

To assist its members and as a reference for other interested parties, the American Petroleum Institute (API) published the *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry* (referred to as the API Compendium) in April 2001[1]. Publicly available and internal company GHG emission estimation protocols were reviewed for use in developing the API Compendium. The resulting document represents a compilation of recognized methodologies for consistent estimation of GHG emissions specific to oil and natural gas industry operations. The initial API Compendium development effort focused on emission estimation methods for carbon dioxide (CO_2) and methane (CH_4), as they represent the vast majority of GHG emissions for petroleum industry operations. The API Compendium presents and illustrates the use of preferred and alternative calculation approaches for CH_4 and CO_2 for all common emission sources, including combustion, point, non-point, non-routine, and indirect sources.

In his Climate Change policy speech of February 2002, President Bush introduced a national commitment to decouple economic growth from GHG emissions and established a target of reducing the nation's GHG intensity by 18% over the next 10 years, when indexed to the gross domestic product (GDP)[2]. The U.S. Oil & Gas Industry, through its leading trade association, API, has embraced the President's challenge by initiating the API Climate Challenge Programs[3].

The API Climate Challenge Programs feature three components:

1) Climate Action Challenge – focusing on strategies for reducing emissions;
2) Climate Research & Development(R&D) Challenge – involving support for enhanced research and development; and
3) Climate Greenhouse Gas Estimation & Reporting Challenge – implementing more robust methods for calculating, reporting and tracking emissions industry-wide.

A critical element of the Climate Challenge Programs is the API Compendium and its role in promoting uniform calculation methods and comparable emission estimates from oil and natural gas industry operations. Using the Compendium, oil and natural gas companies participating in API's GHG Estimation & Reporting Challenge will integrate GHG estimations into operating procedures and report estimates on US emissions to API. API will aggregate member company emissions data for annual reporting and track progress toward the President's goal via GHG-intensity metrics that are meaningful to the industry sectors. Companies will also participate in an expanded API GHG Benchmarking program, which will allow them to compare their progress with sector averages.

CONSISTENCY AND COMPARABILITY IN EMISSION ESTIMATES

Data aggregation, performance evaluation, and identification of trends require consistency in terms of estimation approaches, organizational boundaries, emission sources, and data presentation. These elements are essential to meeting the objectives of API's Climate GHG Estimation & Reporting Challenge Program.

Since the release of the Compendium, a focused comparison study was conducted to identify and understand differences among the various emission estimation approaches as applicable to the global oil and gas industry. Additionally this initiative sought to emphasize the importance of consistency in emission estimation approaches through outreach efforts with other protocol development organizations, particularly those used by the oil and natural gas industry in other regions of the world. Results from the qualitative and quantitative analyses were presented at EPA's 11th Annual Emission Inventory Conference last year[4].

Emission Factor Comparison

The comparison of the various emission estimation protocols entailed different levels of review. In the analysis presented below we focus on the root sources of the emission factors used for estimating GHG emissions to ensure that they are current and transparent in their development and application. We also present the observed variability in a subset of currently used combustion emission factors that have broad application to all industry operations utilizing fossil fuels. Further elaboration of this comparison and the resultant differences in estimated facility-wide emissions, for case studies previously described in detail in the API Compendium, are available in an API report[5].

In addition to the API Compendium, the following protocol documents were included in this comparison:

- Australian Greenhouse Office (AGO), Workbook for Fuel Combustion Activities[6];
- Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) memorandum on "Guide for the Consumption of Energy Survey[7];
- Intergovernmental Panel on Climate Change (IPCC), Guidelines for National Greenhouse Gas Inventories[8];
- UK Emissions Trading Scheme (UK ETS)[9];
- World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD), The Greenhouse Gas Protocol[10].

Combustion of fossil fuels accounts for as much as 85% of national GHG emissions for the US and most other developed countries[11]. Since combustion devices are significant sources of emissions for oil and gas industry operations, as well as many other industries, appropriate CO_2 emission factors are necessary for consistent estimation of emissions from these sources. The quantitative comparison of fossil fuel emission factors provides a basis for demonstrating potential numerical differences resulting from the various data sources.

Comparison Study Results

Three major findings of the comparison study are:

1) Importance of specifying the heating value convention;
2) Variability in fuel-based emission factors and specification of source types; and
3) Consideration of the fractional conversion of carbon to CO_2.

A key finding is that confusion is introduced in the literature due to different conventions for specifying fuels' heating values in different applications globally. The API Compendium specifies the energy content of combustion fuels in terms of 'Higher Heating Values' (HHV), also referred to as the 'Gross Calorific Value'. This convention was chosen to be consistent with AP-42 (EPA, 1995 and subsequent updates)[12] and is the convention most commonly used in the U.S. and Canada. Other protocol documents, especially those outside of North America, utilize fuel data in terms of 'Lower Heating Values' (LHV), also referred to as 'Net Calorific Value'.

Table 1 shows CO_2 emission factors for fuel combustion from several of the protocol documents reviewed. All of the emission factors presented are provided in HHV, or have been converted to a HHV basis, to allow a consistent evaluation of potential differences. In reviewing several of the protocols' reference materials, it was determined that some do not explicitly specify the convention used for the fuel heating value. This has proven to introduce a risk of erroneous application of the emission factors, which may result in a 5% to 10% error in the calculated emissions.

There are some significant differences in the fuel-based CO_2 emission factors in Table 1, as shown in the Variability (%) column. The variability value indicates the spread between the highest and the lowest value reviewed, normalized to the median of the value distribution. More than half of the emission factors show over 5% variability. The most significant differences seem to be associated with combustion of refinery fuel gas and petroleum coke. There does not seem to be any consistent bias; no protocol has consistently higher or lower factors.

These comparisons highlight the importance of obtaining fuel specific data (e.g. composition, heating value, density, etc.) in order to obtain quality results. Published emission factors should be applied carefully to ensure their applicability due to potentially significant variances in the properties of the actual fuels combusted.

Table 1 also shows a difference in the range of fuel types considered by the various protocols. For example, many protocols do not include emission factors for devices that consume still gas, ethanol, of flexi-coker gas. In addition, some protocols group several emission sources into a single emission factor, such as the components of liquefied petroleum gas (LPG). This type of grouping must be understood and appropriately applied if the emission factor is used for estimating emissions.

Another parameter to consider when using CO_2 emission factors for combustion devices is the fractional conversion of carbon in the fuel to CO_2 (sometimes referred to as the fraction oxidized). Two general conventions are in common use: one assumes that all of the carbon is oxidized during the combustion process and emitted as CO_2, while the other presumes a fractional conversion for different fuel types (generally, 99.5% for natural gas and 99% for petroleum fuels and coal). The API Compendium[1] and the WRI/WBCSD[10] use the first approach, assuming total conversion for all combustion sources, with the exception of flares. The second approach is the one used by the IPCC[8] and the U.S. EPA's Emission Inventory Improvement Program (EIIP)[13]. Though the effect of this difference in approach is not as substantial as the impact of specifying different heating values, it still contributes to introducing another element of variability into estimated emissions.

Greenhouse Gas Calculation Tool

A second aspect of API's GHG Estimation & Reporting Challenge under the overall Climate Challenge Programs is the development of a tool for measuring industry's progress towards improved energy efficiency and the national commitments to reducing GHG emissions intensity. Aggregation of industry data requires consistently compiled GHG emission estimates along with throughput/output measures from all participating entities, just as a company requires consistency in aggregating its data for its facilities and business organizations. The availability of a common tool is an essential part of gathering and reporting consistent data and an enabler for further detailed analysis as part of an expanded benchmarking effort being undertaken by API.

In a press release on February 10, 2003, ChevronTexaco announced that its proprietary system for managing GHG emissions and energy utilization data is being made available free of charge to the worldwide energy industry[14]. The system, called the SANGEA™ Energy and Emissions Estimating System 2.0, is an automated, electronic data management system designed to gather GHG emissions and energy usage data from exploration and production, refining and marketing, petrochemicals, transportation, electricity generation, manufacturing, real estate, and coal activities.

ChevronTexaco has used the SANGEA™ emissions estimating system successfully since January 2002. The company began developing this improved reporting system because its assessment determined that there were no comprehensive systems on the market to effectively monitor and measure energy utilization and GHG emission across an organization's various activities. In addition, the system

was designed such that the calculation methods and emission factors of the SANGEA™ system are based on the API Compendium.

Members of the API Greenhouse Gas Emissions workgroup and the API Benchmarking workgroup are evaluating the use of ChevronTexaco's SANGEA™ program to meet two objectives: 1) to support API's Benchmarking group in developing an annual US oil and gas industry inventory using the API Compendium estimation approaches; and 2) as a means of electronic implementation of the estimation methods documented in the API Compendium. The system enables facilities to set up reports, enter monthly data, review results and to revise the reports in a flexible, yet secure, manner when operations change. Another feature of the system is the audit trail information it captures along with input data, thus ensuring the collection and reporting of verifiable data.

OUTREACH EFFORTS AND SPECIAL STUDIES

API is expanding the dialog among oil and gas associations worldwide and within the global oil and gas industry with the goal of achieving consistency in the methodologies for estimating GHG emissions from industry operations. Attaining such global consistency will ensure national and regional comparability in estimation techniques and the eventual fungibility of emission reduction credits among those nations with comparable crediting or trading regimes.

To this end, API has been reaching out to a number of sibling organizations, along with emerging national and international protocol development organizations. For example, API has been collaborating with the World Business Council for Sustainable Development (WBCSD) and World Resource Institute (WRI) in the Compendium development process and has offered the Compendium as the oil and gas industry calculation module for engineering estimates of emissions. API is also active on the US Technical Advisory Group to the International Standards Organization (ISO) which is currently developing an international standard for GHG emissions estimation, reporting and verification.

Global GHG Reporting Guidelines Initiative

The API Compendium focuses on the technical details for estimating GHG emissions and developing GHG inventories. However, the design and harmonization of GHG inventorying and reporting practices also includes decisions on accounting issues, such as scope, extent, boundaries, and threshold. The petroleum industry utilizes some unique operational arrangements that complicate the determination of ownership and inventory boundaries. For example, international oil and gas production in many countries is conducted under "production sharing agreements" which are legally structured as joint ventures but are implemented as income or production taxes.

The International Petroleum Industry Environmental Conservation Association (IPIECA) is collaborating with API, the International Association of Oil and Gas Producers (OGP), and petroleum industry companies to produce an industry-endorsed approach for reporting operational emissions from industry facilities and businesses. The proposed "Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions" document is intended to complement the API Compendium, so that when used together the two documents will enable consistent development of GHG inventories by individual companies within the petroleum industry. The first edition of the guidelines will be developed during 2003 and will accomplish the following:

- Define principles for transparent, comparable, consistent, cost-effective and reliable accounting of corporate, business or facility (entity) emissions;

- Account for differences in emissions ownership, especially in situations unique to the petroleum industry, such as production lease sharing agreements, tolling arrangements, and outsourcing arrangements;
- Recommend boundaries for direct and indirect GHG emissions, including purchased power and heat/steam;
- Recommend processes to establish and revise baselines, where appropriate;
- Recommend treatment of emissions inventories to reflect retrospective business portfolio changes;
- Recommend levels of estimation reliability (accuracy and completeness);
- Recommend assurance processes for confirming integrity of inventories;
- Provide guidance on objective and target setting for GHG emission reductions;
- Determine those GHG species applicable to a company; and
- Provide guidance on normalizing absolute emissions, e.g. relative to output or throughput.

CONCLUSIONS

Robust methods for calculating, reporting, and tracking emissions are essential for cost-effectively managing GHG emissions. Consistent methodologies lend credibility to the estimates and enable aggregation and comparison. Initial "road testing" of the API Compendium and special studies undertaken to compare it to other commonly used protocols further support the pursuit of consistency. These activities also provide valuable insight into enhancements for the API Compendium and have spurred new initiatives to progress toward harmonization of methodologies and improved global compatibility of oil and gas industry emission estimates.

The main conclusion from the comparison study is that GHG emission inventories can be significantly different due to the approach used to calculate emissions and the assumptions governing the choice of sources, fuels and operating practices. This is particularly important for combustion sources that generally comprise the majority of emissions from an entity's inventory. 'Transparency' is a key issue as many of the protocol documents do not have sufficient detail to understand the derivation of the emission factors. Careful documentation of the underlying conditions and assumptions is necessary to ensure proper implementation of the guidance provided by the protocols.

Quantitative comparisons, in which the application of the protocols was demonstrated for a range of industry example facilities, enable a better understanding of differences noted in a mere qualitative assessment. Primary contributors to the differences observed both in the qualitative and quantitative comparisons among the various protocols are attributed to:

- Omission of some emission source types from several of the protocols,
- Differences in emission factors recommended, due to the sources included or the information cited, and
- Hierarchy of the different "tiers" or levels of emission factors – where some of the protocols lump several emission sources into one emission factor.

NEXT STEPS

With the interest in addressing climate change issues gaining momentum, API members will continue to refine and promote a common global methodology for estimating GHG emissions within the industry. A revised version of the API Compendium is planned for late 2003. Enhancements to the document will include the following:

- Reporting all emission factors in terms of International System of Units (SI), in addition to the existing unit convention, to increase the global applicability of the API Compendium;
- Presenting CO_2 emission factors for fuels both in terms of LHV, in addition to the existing HHV, fuel heat content conventions, to increase awareness and allow for correct applicability of appropriate approaches globally.
- Updating the discussion of electricity emission factors to address additional information sources and to include international electricity "grid" emission factors;
- More detailed source-specific emission factors for vented and fugitive emissions to accommodate emission reduction calculations; and
- Including emission estimation approaches for other petroleum industry sources such as: geothermal steam and electricity production, produced water, drilling fluid, casing gas, pipeline pigging, and natural gas distribution systems.

API is pursuing separate special studies on refinery fugitive CH_4 emissions and N_2O emissions from combustion sources. These studies aim to provide data for determining circumstances in which these emission sources may be negligible. Results from these two studies are also expected later this year.

API welcomes a continuing open exchange of information and a broad discussion of the GHG emission estimation methodologies for the Oil and Natural Gas industry. (To obtain a copy of the API Compendium see: www.global.ihs.com). The API Greenhouse Gas Emissions Methodology Working Group is coordinating internally with the API Benchmarking Workgroup to support aggregating industry emissions and develop a Compendium software tool. API is also collaborating with IPEICA to develop industry specific reporting guidelines. These activities will continue throughout this year and support API's overall objectives of achieving global consistency in GHG emissions reporting for the oil and gas industry.

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Table 1. Comparison of CO_2 emission factors for fuel combustion: common industry fuel types.

		Metric Tons of CO2 / MMBTU (HHV)					
Variability (%)	Fuel Types	API CO_2 Emission Factor[1]	AGO Workbook 1.1 (Table 4)	IPCC Volume 3 (Table 1-1)	DEFRA, Protocol[1]	WRI/ WBCSD[2]	CIEEDAC
3.6	Aviation Gas	0.0692	0.0717		0.0703	0.0693	
14.4	Bitumen	0.0810	0.0851	0.0808	0.0879	0.0931	
35.2	Coke (Coke Oven/Gas Coke)	0.1085	0.1260	0.1083	0.0879	0.1083	0.0893
5.4	Crude Oil	0.0743		0.0734	0.0703		
6.4	Distillate Fuel	0.0732	0.0718		0.0703	0.0732	0.0750
11.9	Electric Utility Coal	0.0994	0.0966		0.0879		
-	Ethanol	0.0700					
-	Flexi-Coker/ Low Btu Gas	0.113					
1.4	Gas/Diesel Oil	0.0742	0.0735	0.0742	0.0732	0.0732	
2.8	Jet Fuel	0.0723	0.0717		0.0703	0.0709	
4.4	Kerosene/Aviation Kerosene	0.0723	0.0735	0.0716	0.0703	0.0724	
3.8	Lignite	0.0976		0.1013		0.0977	
2.7	LPG	0.0629	0.0626	0.0632	0.0615	0.0631	
2.9	Butane	0.0668					0.0649
5.3	Ethane	0.0597		0.0617	0.0586		
11.6	Propane	0.0704				0.0631	0.0632
2.8	Misc. Petroleum Products and Crude	0.0721	0.0723		0.0703		
2.5	Motor Gasoline	0.0712		0.0694	0.0703	0.0710	
9.7	Naphtha (<104°F)	0.0665	0.0696	0.0734	0.0761		
0.0	Nat Gas Liquids	0.0632		0.0632			
6.8	Natural Gas	0.0531	0.0542	0.0532	0.0556	0.0531	0.0520
7.3	Other Bituminous Coal	0.0931		0.0947	0.0879	0.0931	
0.3	Other Oil (>104°F)	0.0732		0.0734			
-	Pentanes Plus	0.0669					
37.3	Petroleum Coke	0.102	0.1260	0.1010	0.0879	0.1021	0.0987
26.4	Refinery Fuel Gas	0.057	0.0718		0.0586		0.0566
11.0	Residual Fuel	0.0788	0.0718	0.0775	0.0703	0.0789	
-	Special Naphtha	0.0728					
-	Still Gas	0.0642					
8.9	Sub-bituminous Coal	0.0963		0.0962	0.0879	0.0965	
-	Unfinished Oils	0.0742					

[1] Primarily taken from EIIP, 1999.

[2] Cites heating value and other fuel property conversion factors from EIA, *Annual Energy Review*, and US Department of Energy, 2000.

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