AMERICAN PETROLEUM INSTITUTE

EPA 19th International Emission Inventory Conference
September 28-30, 2010
San Antonio, Texas

Understanding Uncertainty in Greenhouse Gas Emission Estimates: Technical Considerations and Statistical Methods

K. Ritter, American Petroleum Institute

T. Shires, URS Corporation

M. Lev-On, The LEVON Group

A Decade of Initiatives …

- Petroleum Industry Guidelines for Reporting GHG Emissions
- Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry (API GHG Compendium)
- Petroleum Industry Guidelines for GHG Emission Reduction Projects


Prepared by the LEVON Group, LLC and URS Corporation

ADDRESSING UNCERTAINTY IN
OIL AND NATURAL GAS INDUSTRY
GREENHOUSE GAS INVENTORIES

TECHNICAL CONSIDERATIONS
AND CALCULATION METHODS

SEPTEMBER 2009
PILOT TEST VERSION

IPIECA
INTERNATIONAL PETROLEUM INDUSTRY
ENVIRONMENTAL CONSERVATION ASSOCIATION

energy API
AMERICAN PETROLEUM INSTITUTE

concawe

Uncertainty Document

Role of Uncertainty Analysis

- Increasingly recognized as an important tool for improving GHG emission inventories and reduction quantification
- EU-ETS specifies a tiered approach
  - Facilities emitting 50,000 – 500,000 tonnes fossil CO_2: uncertainty ranges are 7.5% (Tier 1), 5% (Tier 2), and 2.5% (Tier 3)
  - Facilities emitting > 500,000 tonnes fossil CO_2: uncertainty of 1.5% (Tier 4)
- EPA GHG MRR requires flow meters calibrated to 5% accuracy

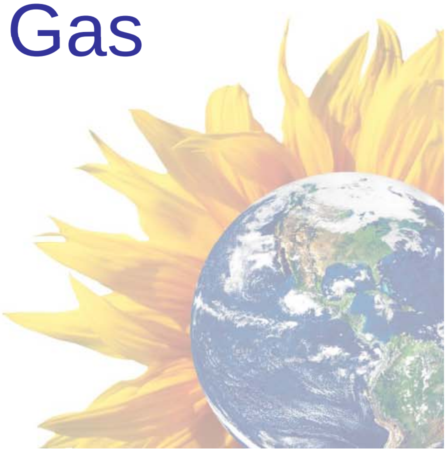
energy API
AMERICAN PETROLEUM INSTITUTE

Rationale for Developing the Uncertainty Document

- Provide companion document for API Compendium and Industry Guidelines
- Improve GHG assessments
- Enhance confidence of attaining compliance
- Focus data collection resources
- Assess applicability of existing emission factors
- Simplify statistical calculation approach

About the Uncertainty Document

- Technical considerations for uncertainty analysis at the facility and entity level
- Sources of GHG inventory uncertainty
- Role of industry practices and standards
- Approaches for calculating uncertainty
- Methods for error propagation
- Example applications for Oil & Natural Gas inventories



AMERICAN PETROLEUM INSTITUTE

Uncertainty Document Organization

Section 1 - Introduction

Section 2 – Sources of Uncertainty

Section 3 – Overview of Measurement Practices

Section 4 – Statistical Calculation Methods

Section 5 – Calculation Examples

Appendices

- **A** – Glossary of Statistical and GHG Inventory Terms
- **B** – Flow Meters Inspection & Maintenance
- **C** – Measurement Methods Summaries
- **D** – Units Conversion
- **E** – Calculation details for example inventory

energy API
AMERICAN PETROLEUM INSTITUTE

Quantifying Uncertainty

- General Steps
  - Determine the uncertainty for measured data
  - Determine the uncertainty for emission factors data
  - Aggregate uncertainties
- Statistical calculation methods provided with guidance to applicability
- Decision trees used to help navigate
- Pertinent examples embedded in text
- Reference to industry standards with accuracy information

Example 1:

Comparison of Annual CO_2 Emissions

- Assume annual CO_2 emissions are based on the product of the fuel consumption (activity) times the Tonnes CO_2/fuel volume (EF)
- Compare emission estimate results from three approaches:
  1. Annual flow and default EF
  2. Annual flow and annual average carbon content
  3. Monthly flow and composition samples
- Addresses flow measurement uncertainty for different methods used, uncertainty of generic EF (10%), and uncertainty for gas sampling

energy API
AMERICAN PETROLEUM INSTITUTE

Example 1: Annual Emission Results

Method	Emissions, tonnes CO_2	Uncertainty (rel) ± %	Confidence Range, tonnes CO_2
1. Annual flow and EF	**66,251**	**18.09%**	**54,266 – 78,236**
2. Annual flow and annual average carbon content	**65,567**	**11.69%**	**57,902 – 73,232**
3. Monthly flow and composition samples	**65,551**	**3.91%**	**62,988 – 68,114**

Example 1: Results Discussion

- Annual CO_2 emissions calculated are only ~ 1% apart
- Statistically, the annual emissions calculated are all equal
  - They have overlapping confidence intervals
- Using the generic EF results in the highest (most conservative) emission estimate
- Measurements uncertainty depends on the variability and reproducibility of the methods used
- Monthly approach exhibits lowest uncertainty ranges due to sum of squares aggregation

Example 2: Comparison of FCCU Emission Estimation Methods

- Assume: A catalytic cracking unit has a coke burn rate of 119,750 tonnes per year ± 15% and a blower air capacity of 2,150 m^3/min ± 15%
  - Both uncertainties assigned by expert judgment
- Compare emission estimate results

1. Coke burn rate and carbon fraction in coke

$$E_{CO_2} = \text{Coke Burn}_{Avg} \times CF \times \frac{44 \text{ mass units } CO_2/\text{mole}}{12 \text{ mass units C/mole}}$$

2. EPA Rule 40 CFR 63 Subpart UUU "K1, K2, K3"

$$E_{CO_2} = \left[K_1 \times Q_r \times \left(P_{CO_2} + P_{CO}\right)\right] \times \frac{44 \text{ mass units } CO_2/\text{mole}}{12 \text{ mass units C/mole}} \times H$$

3. Air blower capacity and flue gas concentration

$$E_{CO_2} = \left(AR + SOR\right) \times \left(FCO_2 + FCO\right) \times \frac{44}{\text{molar volume conversion}} \times H$$

Example 2:
FCCU Emission Results

Method	Emissions, tonnes CO_2	Uncertainty (rel) %
Coke burn rate and C faction in coke	**454,864**	**14.4%**
“K_1, K_2, K_3” approach	**458,378**	**14.3%**
Air blower capacity and flue gas concentration	**466,375**	**14.4%**

- Annual CO_2 emissions calculated are ~2.5% apart
  - Statistically, the annual emissions calculated are all equal
- Overall uncertainty is driven by 15% value assigned by expert judgment to coke burn rate and air blower capacity

Summary

- Uncertainty analysis is a tool to assess the confidence range for reported GHG emissions
- The analysis is usually a blend of statistical calculations aided by expert judgment
- It is an excellent tool for
  - Understanding the main contributors to errors
  - Enable targeting large contributing sources for more intense data collection
  - Devising strategies to improve GHG inventories

Next Steps

- Uncertainty Document
  - Completed as a Pilot Version August 2009
  - Open for comments and 'road-testing'
  - Update in 2011-2012
- API Standards Development
  - API's Committee on Petroleum Measurements (COPM) developing background documents for recommended practices
    - Fuel gas measurement systems for GHG reporting
    - Standard methods for calculating carbon content of petroleum products
  - The first of these documents is expected in November 2010; the second to follow

energy API
AMERICAN PETROLEUM INSTITUTE

Thank you for your attention

For additional information:

Karin Ritter, API
Ritterk@api.org
(202) 682-8472

Terri Shires, URS
Terri_Shires@URSCorp.com
(512) 419-5466

http://www.api.org/ehs/climate/response/upload/Addressing_Uncertainty.pdf

http://www.ipieca.org/system/files/publications/addressing_uncertainty_pilot.pdf

AMERICAN PETROLEUM INSTITUTE