Promoting Global Consistency in Estimating Greenhouse Gas Emissions from Oil & Gas Industry Operations

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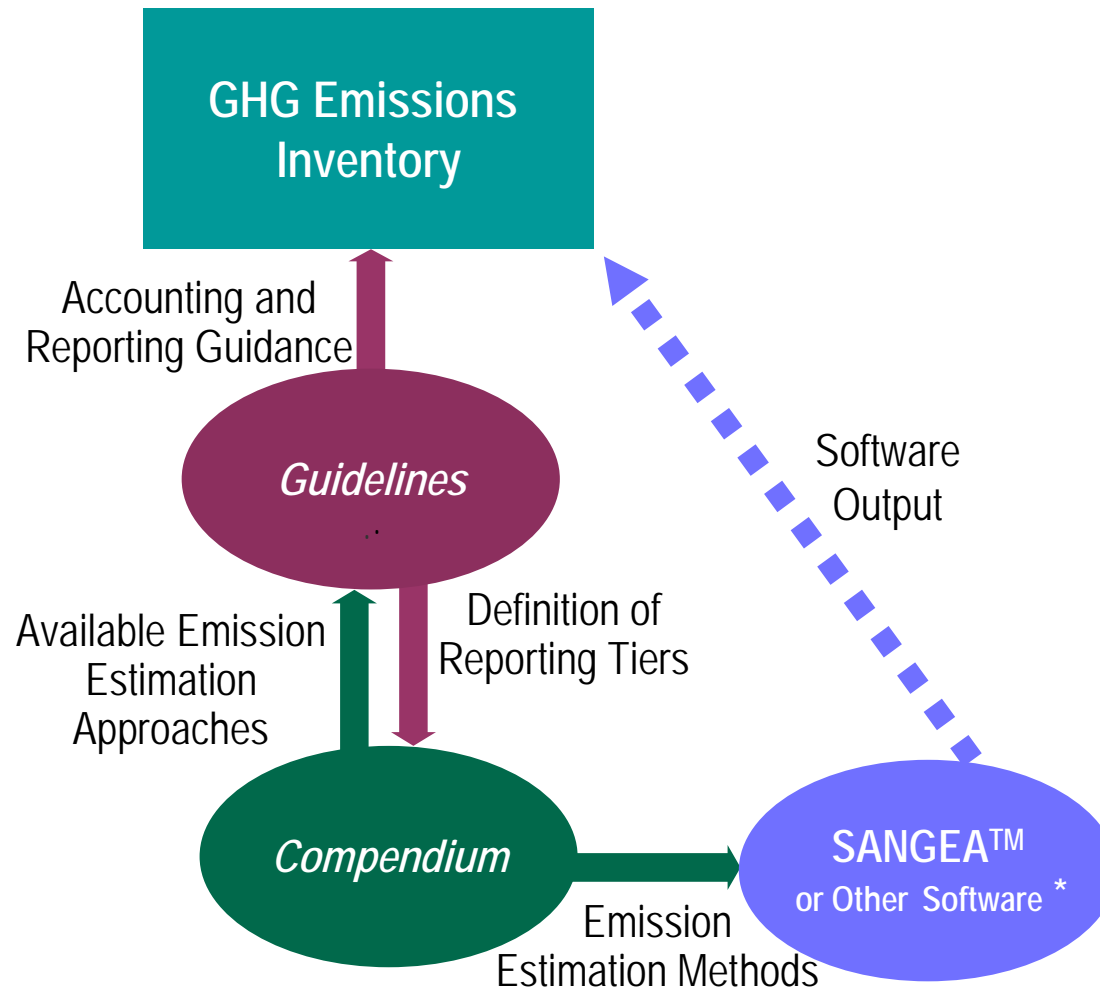Presented by: Christopher J. Loughran, P.E., URS Corporation

Overview

- **Importance of Emissions Inventories**
- **IPIECA/API/OGP Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions**
- **2004 API Compendium of Greenhouse Gas Emissions Estimation for the Oil and Gas Industry**
- **SANGEA™ Energy and Emissions Estimating System**

An Approach to Consistent Emissions Estimating

GHG Emissions Inventory

Accounting and Reporting Guidance

Guidelines

Software Output

Available Emission Estimation Approaches

Definition of Reporting Tiers

Compendium

SANGEA™ or Other Software *

Emission Estimation Methods

*Emission calculations made following Guidelines accounting and reporting procedures and Compendium emission estimation methods.

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Development of the Guidelines

- **Voluntary guidelines for the accounting and reporting of GHG emissions from petroleum operations**
  - Accounting - recognition and consolidation of GHG emissions
  - Reporting - presentation of GHG data in formats tailored to the needs of various reporting uses
- **Based on WRI/WBCSD GHG Protocol**
- **Workshop and review with industry peers**
- **Customized for petroleum industry**
  - Discusses cost effectiveness and materiality in relation to completeness and accuracy.

Guidelines Overview

- **Accounting and Reporting Principles**
  - Completeness
  - Accuracy
  - Consistency
  - Relevance
  - Transparency
- **Setting the Boundaries**
- **Designing an Inventory to Monitor Performance**
- **Identification of Industry Emissions**
- **Evaluation of Oil & Gas Industry Emissions**
- **GHG Emissions Reporting**
- **Inventory Assurance Processes**

Operational Boundaries

- **Direct Emissions – from sources owned or operated by reporting company**
  - Combustion
  - Process emissions
  - Transportation
  - Fugitive losses
- **Indirect Emissions (optional) – consequence of reporting company but from sources owned by other parties**
  - Consumption of purchased energy
- **Other Indirect Emissions (optional)**
  - Contractors
    - Drilling
    - Well maintenance
    - 3rd party shipping
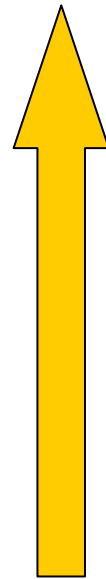
Accuracy and Methodologies

- **Link between Guidelines and Compendium**

- **Guidelines Tiers**

  - Tier A: 10-30%

  - Tier B: 20-40%

  - Tier C: 30-60%

**Improved accuracy
Increasing level of
effort and cost**

Estimation Options for Combustion

Source Category	GHG	Estimation Tiers		
		Tier C	Tier B	Tier A
		Estimation Approach		
		(increasing accuracy) →		
Combustion Sources	CO2	Fuel consumption based on ratings, hours of operation and assumed loads for engines/turbines (energy balance for boilers/heaters); [*Demonstrated in Compendium Exhibit 3-3*]	Fuel consumption based on ratings, hours of operation and loads for engines/turbines (energy balance for boilers/heaters); [*Demonstrated in Compendium Exhibit 3-3*]	Fuel consumption based on single point metering and integrating mass flow for fuel gas, purchase records or tank measurements for commodity fuels (e.g., natural gas, diesel); [*Compendium Section 4.2.*
		Or default emission factors; [*Compendium Section 4.2 Demonstrated in Exhibits 4.3 and 4.5*]	Or fuel emission factors (mass/mass or mass/heating value) based on default factors. [*Compendium Section 4.2. Demonstrated in Exhibits 4.3 and 4.5*	Or fuel emission factors (mass/mass or mass/heating value) based on default factors. [*Compendium Section 4.2. Demonstrated in Exhibits 4.3 and 4.5*]
				Or factors based on actual measurements of fuel composition if available [*Compendium Section 4.1. Demonstrated in Exhibit 4.1*]
	CH4	Not considered [*CH4 emission factors are provided in Compendium Section 4.3. Calculations are demonstrated in Exhibit 4.7. Small contribution of CH4 from combustion sources is demonstrated in Compendium Section 7*		

API Compendium of GHG Emissions Estimation Methodologies

- **Objectives –**
  - Promote consistency in estimating petroleum company's GHG emissions
  - Provide technical expertise on existing methodologies and ways to improve and streamline GHG emission estimates
- **Terms of Reference**
  - Review and evaluate existing methods and calculation approaches
  - Provide recommendations on preferred and alternate methodology

Compendium Project Background

- **Emissions Methodology Workgroup established in 1999 to work with the Climate Steering Committee**
- **Initial Pilot Test Version – April 2001**
- **Revised Compendium – February 2004**
- **Structure**
  - Multi-sector petroleum industry participation to ensure coordinated industry effort
- **Mandate**
  - Focus on industry sources
  - Concentrate on CO_2 and CH_4

Compendium At A Glance

- **By source category**
  - Combustion emissions
  - Vented emissions
  - Fugitive emissions

- **By industry segment**
  - Exploration and Production
  - Transportation and Distribution
  - Refining

- **Preferred vs. alternative methods**
  - Decision trees to guide method selection
  - Sample calculations to demonstrate computational approaches
  - Case Studies to demonstrate aggregation

Typical Methods Hierarchy

Types of Approaches	Hierarchy
Published emission factors	
Equipment manufacturer emission factors	
Engineering calculations	**Improved accuracy**
Monitoring over a range of conditions and deriving emission factors	**Additional data requirements** **Higher cost**
Periodic monitoring of emissions or parameters for calculating emissions	
Continuous emission monitoring *	

*Applies broadly to most types of air emissions, but may not be directly applicable nor highly reliable for GHG emissions.

2004 Compendium Revisions – Emission Factor Details

- **Reviewed/revised factors based on latest guidance**
- **Added N_2O factors**
- **Enhanced international application**
  - SI and US units
  - Country/regional specific emission factors
- **Uncertainty values**
- **Fuel-based CO_2 emission factors in HHV and LHV**
- **Composite country/regional electric grid emission factors**
- **Additional power output to energy input factors (engines)**

2004 Compendium Revisions – Emission Sources

- **Additional petroleum-sector activities**
  - Minerals and mining operations
  - Petrochemical manufacturing
- **More detailed, source-specific vented and fugitive emission factors**
- **Additional industry sources**
  - CH_4 tank blanketing
  - Produced water
  - Exploratory drilling and well testing
  - Pipeline pigging
  - Natural gas distribution systems

SANGEA™ Energy and GHG Inventory System

- **Enables data collection, computation, compilation, and reporting**

- **Excel-based, compatible with standard Personal Computer (PC)**

- **Single system for all facilities**

- **User can choose input and output units (metric, English, mass, volume)**

- **Flexible level of detail/aggregation**

- **Based on API 2004 methodologies**

SANGEA™ Software

- **Gases Included**
  - Carbon Dioxide
  - Methane
  - Nitrous Oxide
- **Emission Sources Included:**
  - Onsite fuel consumption
  - Process emissions
  - Flaring
  - Venting
  - Fugitive Emissions
  - Indirect Emissions
  - Onsite Waste Treatment

- **Organizational Boundaries**
  - Operated Only
  - Equity Basis
- **Operational Boundaries**
  - Direct Emissions
  - Indirect Emissions
  - Energy export

Designed to be compatible with the Guidelines and the Compendium

Example SANGEA™ Software Main Menu

Example Refinery - Energy & Emissions Estimating System - Main Menu

Spreadsheet Configuration | Help Topics | User Maintenance | File Maintenance

Step 1.
Setup of Reporting Entity, Primary Production Measure and Primary Users.   Complete.   [Modify]

Step 2.
Specification of Locations, Location Groups.   [Add]   [Modify]   [Remove]

Maintenance of Secondary Production Measures.   [Add]   [Modify]   [Remove]

Step 3.
Installation of Modules required for Evaluation of Emissions.   [Add]   [Remove]

Step 4.
Configuration of Emission Sources for Installed Modules.   [Configure Sources]

Step 5.
☑ Enter or Review Input Data and Audit Trail Information.   Select Location [▼]

☐ Review Emission Data.

☐ Update or View Internal Report.   Select Location Group [▼]

Step 6.
Check All Input Data and Audit Trail Information Entered.   [Check Data Ready]

Step 7.
Quarterly Sign Off and Generation of Corporate Report.   [Sign Off & Report]

☐ Disable Main Menu   [Exit Menu]

Allows specification of operator or equity ownership

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Example SANGEA™ Software Main Menu – Source Module Configuration

Module Configuration

Module Name	Description
Acid Gas Removal	Emissions from the Treatment of Gas to Remove Acid Gases (carbon dioxide and hydrogen sulfide)
Coke Combustion	Emissions from Coke Combustion during the Regeneration of Catalytic Cracker and Other Catalysts an
Combustion	Emissions from Combustion of Fuels and Wastes (other than flaring)
Crude Oil	Emissions from the Transport and Storage of Crude Oil
Flare	Emissions from Flares while both Lit and Unlit
Flashing	Emissions from Tank Flashing of Crude Oils
Fugitive	Emissions from leaks of Gases from such equipment as Valves, Flanges, Connectors, Open Ended Line
Glycol Dehydrator	Emissions from Methane Resulting from the Treatment of Gas to Remove Moisture
Hydrogen Plant	Emissions from Conversion of Hydrogen Plant Feedstock to Hydrogen
Indirect Emission	Emissions or Emission Credits from the Import and Export of Steam and Electricity
Miscellaneous	Emissions from Coal Mining and Wastewater Treatment and Emissions or Credits from Miscellaneous Sou
Venting	Emissions from processes other than Combustion or Chemical Reactions, including specific devices and

Install   Cancel   Help

Select the sources at your facility

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Example SANGEA™ Software Combustion – Source Configuration

Example SANGEA™ Software Combustion – Default Emission Factors

A	K	Device Rating			Units				
		Lower Limit	Upper Limit	Units					
Selected Standard Fuels	Device Type	Lower Limit	Upper Limit	Units	CO2 Factor	CH4 Factor	N2O Factor	Emission	Fuel
Natural Gas	General				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Boiler or Furnace				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Wall Fired Boiler >10^8 Btu/hr: Uncontrolled (	100		10^6 Btu/Hr	117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Wall-Fired Boiler >10^8 Btu/hr: Uncontrolled (	100		10^6 Btu/Hr	117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Wall-Fired Boiler >10^8 Btu/hr: Controlled--Lc	100		10^6 Btu/Hr	117.65	0.002250	0.000627	lb	10^6 Btu (HHV)
	Wall-Fired Boiler >10^8 Btu/hr: Controlled--Fl	100		10^6 Btu/Hr	117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Small Boiler <10^8 Btu/hr: Uncontrolled		100	10^6 Btu/Hr	117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Small Boiler <10^8 Btu/hr: Controlled--Low NOx burners		100	10^6 Btu/Hr	117.65	0.002250	0.000627	lb	10^6 Btu (HHV)
	Small Boiler <10^8 Btu/hr: Controlled--Low NOx burners/Fl		100	10^6 Btu/Hr	117.65	0.002250	0.000627	lb	10^6 Btu (HHV)
	Tangential-Fired Boilers (all sizes): Uncontrolled				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Tangential-Fired Boilers (all sizes): Controlled--Flue gas recirculation				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Residential Furnaces <3x10^5 Btu/hr		0.3	10^6 Btu/Hr	117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke lean burn)				117.65	1.25	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke lean burn, 90-105% Load)				117.65	1.25	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke lean burn, <90% Load)				117.65	1.25	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke rich burn)				117.65	0.23	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke rich burn, 90-105% Load)				117.65	0.23	0.002157	lb	10^6 Btu (HHV)
	Engine (4-stroke rich burn, <90% Load)				117.65	0.23	0.002157	lb	10^6 Btu (HHV)
	Engine (2-stroke lean burn)				117.65	1.45	0.002157	lb	10^6 Btu (HHV)
	Engine (2-stroke lean burn, 90-105% Load)				117.65	1.45	0.002157	lb	10^6 Btu (HHV)
	Engine (2-stroke lean burn, <90% Load)				117.65	1.45	0.002157	lb	10^6 Btu (HHV)
	Turbine				117.65	0.00860	0.0030	lb	10^6 Btu (HHV)
	Gas Turbine: Uncontrolled				117.65	0.00860	0.0030	lb	10^6 Btu (HHV)
	Gas Turbine: Controlled--Water-Steam Injection				117.65	0.00860	0.0030	lb	10^6 Btu (HHV)
	Gas Turbine: Controlled--Lean-Premix				117.65	0.00860	0.0030	lb	10^6 Btu (HHV)
Fuel Gas	General				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Boiler or Furnace				117.65	0.002250	0.002157	lb	10^6 Btu (HHV)
	Engine				117.65	0.005600	0.003672	lb	10^6 Btu (HHV)
	Turbine				117.65	0.0086	0.003000	lb	10^6 Btu (HHV)
Field Gas (associated or	General				123.6	0.00251	0.0024	lb	10^6 Btu (HHV)
	Boiler or Furnace				123.6	0.00251	0.0024	lb	10^6 Btu (HHV)
	Engine				123.6	0.0024	0.0024	lb	10^6 Btu (HHV)
	Turbine				123.6	0.009573	0.00334	lb	10^6 Btu (HHV)
Flash Gas	General				130.3	0.00251	0.0024	lb	10^6 Btu (HHV)
Butane	General				146.8	0.0021	0.0092	lb	10^6 Btu (HHV)

Sheet1 / Sheet2 / Sheet3

Enter fuel-specific emission factors here

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Example SANGEA™ Software Input Data Screen

Enter monthly input data

Location	Source Description	Source Id		Units	YTD	Jan	F
Enter Monthly Usage for: Waste Gas							
Example	Incinerators	3		10^6 Btu (HHV)	344,000	344,000	
Enter Monthly Usage for: Natural Gas for Turbines							
Example	Gas Turbines	2		10^6 Btu (HHV)	7,140,000	7,140,000	
Enter Monthly Usage for: Refinery Fuel Gas							
Example	External combustion boilers/heaters	1		10^6 Btu (HHV)	45,762,500	45,762,500	
Enter Monthly Usage for: Purchased Natural Gas							
Example	IC Engines	1		10^6 Btu (HHV)	672,000	672,000	
Enter Monthly Usage for: Natural Gas							

Hydrogen Plant Sources Input Data
Enter Monthly Hydrogen Production For Feedstock Specified:

Location	Source Description	Source Id	Feedstock	Units	YTD	Jan	F
Example	Natural gas feed to H2 plant	1	Natural Gas	10^6 scf	6,600	6,600	

Location	CO$_2$	CH$_4$	N$_2$O	CH$_4$ (CO$_2$e)	N$_2$O (CO$_2$e)	Total CO$_2$e	Energy (10^6Btu (LHV))
Field 123 Well 55 Processing	2,266,147	4,128	440.2	86,687	136,461	2,489,295	668,585
Field 123 Well 56 Processing	523,001	43	0.0	895	0	523,895	0
Field 321 Well 77 Processing	414,988	18	0.8	380	238	415,607	728,363
Field 321 Well 66 Processing	80,505	43	0.0	895	0	81,400	0
Total (tonne):	**3,284,641**	**4,231**	**441.0**	**88,857**	**136,699**	**3,510,197**	**1,396,948**

Module	CO$_2$	CH$_4$	N$_2$O	CH$_4$ (CO$_2$e)	N$_2$O (CO$_2$e)	CO$_2$e	Energy (10^6Btu (LHV))
Acid Gas Removal	241,516	128	n/a	2,684	n/a	244,200	n/a
Coke Combustion	1,259,175	n/a	n/a	n/a	n/a	1,259,175	n/a
Cold Vent	11	67	n/a	1,415	n/a	1,425	n/a
Combustion	175,637	21	3.3	435	1,009	177,081	2,956,991
Flare	1,031	6	0.0	127	0	1,158	n/a
Flashing	1,515	6	0.0	121	0	1,636	n/a
Fugitive	n/a	2,621	n/a	55,039	n/a	55,039	n/a
Glycol Dehydrator	n/a	21	n/a	447	n/a	447	n/a
Hydrogen Plant	177,848	n/a	n/a	n/a	n/a	177,848	n/a
Indirect Emission	1,462,820	197	171.3	4,141	53,106	1,520,066	-1,560,043
Crude Oil	n/a	129	n/a	2,702	n/a	2,702	n/a
Miscellaneous	-34,911	1,036	266.4	21,748	82,584	69,420	n/a
Total (tonne):	**3,284,641**	**4,231**	**441.0**	**88,857**	**136,699**	**3,510,197**	**1,396,948**

CO$_2$ (by Location & Module)	Acid Gas Removal	Coke Combustion	Cold Vent	Combustion	Flare	Flashing	Fugitive	Glyco...
Field 123 Well 55 Processing	80,505	408,340	11	132,988	1,031	1,515	n/a	
Field 123 Well 56 Processing	80,505	442,495	0	0	0	0	n/a	
Field 321 Well 77 Processing	0	408,340	0	42,648	0	0	n/a	
Field 321 Well 66 Processing	80,505	0	0	0	0	0	n/a	
Total (tonne):	**241,516**	**1,259,175**	**11**	**175,637**	**1,031**	**1,515**	**0**	

CH$_4$ (by Location & Module)	Acid Gas Removal	Coke Combustion	Cold Vent	Combustion	Flare	Flashing	Fugitive	Glyco...
Field 123 Well 55 Processing	43	n/a	67	3	6	6	2,621	
Field 123 Well 56 Processing	43	n/a	0	0	6	0	0	
Field 321 Well 77 Processing	0	n/a	0	18	0	0	0	
Field 321 Well 66 Processing	43	n/a	0	0	0	0	0	
Total (tonne):	**128**	**0**	**67**	**21**	**6**	**6**	**2,621**	

Example SANGEA ™ Software Summary Chart -Emissions by Module
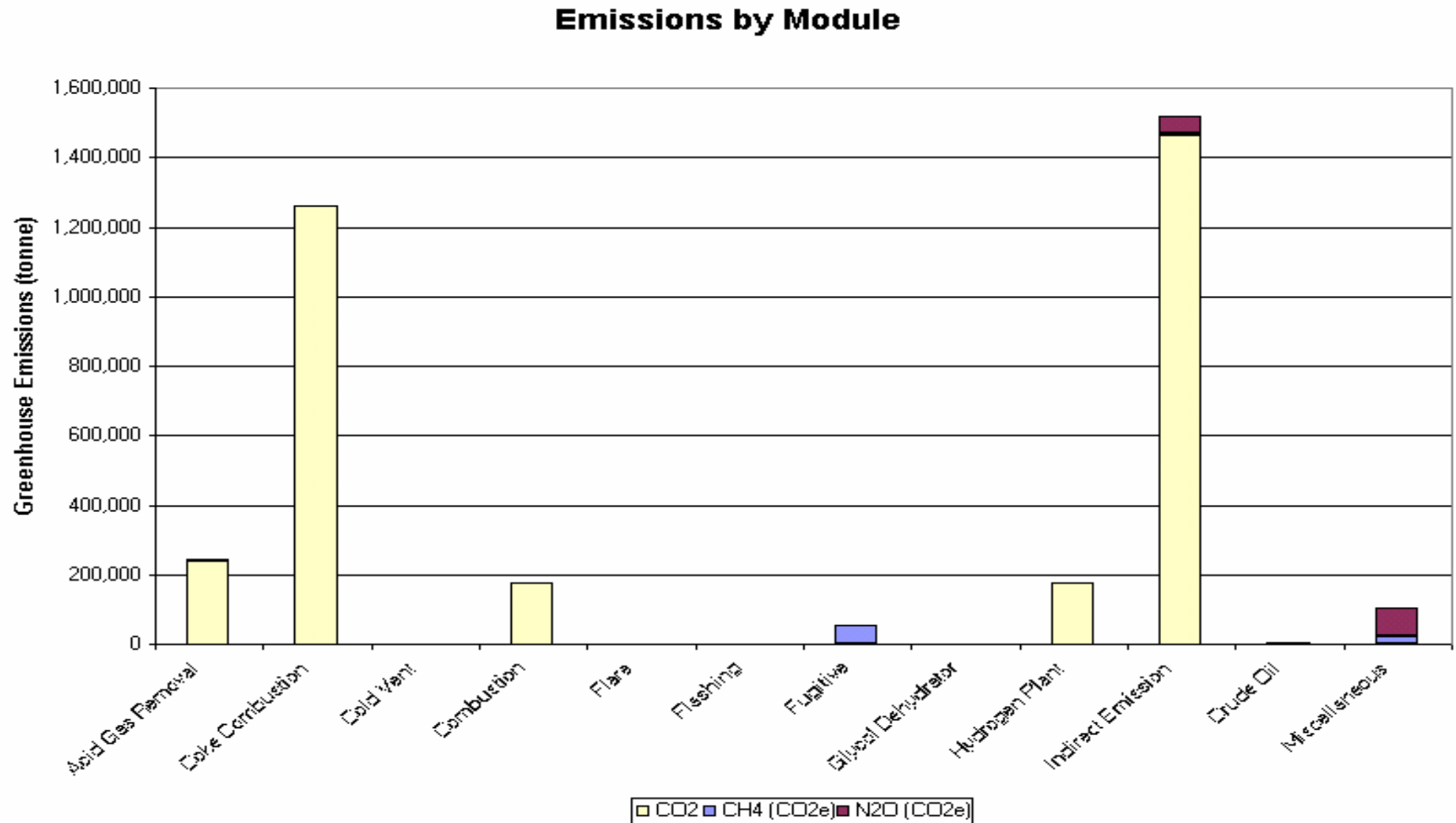
Summary

- **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**

- **Petroleum Industry has taken significant steps toward consistency**
    - Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions
    - API Compendium of Greenhouse Gas Emissions Estimation for the Oil and Gas Industry
    - SANGEA™ Energy and Emissions Estimating System

Path Forward

- **SANGEA™ software will be available through API**
- **Workshops and conference participation to publicize Compendium, Guidelines, and SANGEA™ software**
- **Periodic updates to Compendium, Guidelines, and SANGEA™ software**
- **Continued outreach to ensure consistency**
  - DOE 1605(b)
  - ISO 14064
  - IPCC
- **Examine applications to emission reduction projects**

Access to GHG Tools

- **Guidelines Document**
  - http://api-ec.api.org

  or
  - http://www.ipieca.org/reporting/ghg.html

  or
  - http://www.ogp.org.uk
- **Compendium**
  - http://api-ec.api.org
- **SANGEA™ software**
  - http://api-ec.api.org

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