Inventorying Your Greenhouse Gas Emissions
Extracting Maximum Value With A Tier IV Methodology

Presented by

ICF Consulting

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Outline for Discussion

- **Why Do Inventories?**
- Maximizing Value Through Advanced Inventory Methodologies: Basic Principles
- ICF's Tier IV GHG Inventory Methodology (GEMS™) for Gas and Oil Companies

Purpose of Inventories

- Establish an emissions footprint
- Report emissions
- Manage emissions

Managing Emissions

- Know sources by equipment
- Understand processes
- Know how emissions are affected by changes in processes or equipment
- Understand costs
- Compile and analyze emissions across reporting units
- Compare annual changes and reasons

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GHG Inventory System:
Extract Maximum Value From Your Investments

- **Any inventory system should do more than just estimate emissions**
  - It should automate assembly of data
  - It should automate baseline and year-to-year comparisons
  - It should analyze changes
  - It should easily adapt to changes
- **Above all, it should allow evaluation of investment opportunities**

GHG Inventory System (cont'd)

- **A complete GHG inventory system c*onsists of:***
  - ***Protocols:***
    - Methodology: all sources, set of emission estimation equations and parameters (data)
    - Baseline/Reference Case: the historical start-up year (corporate) or "BAU/without project" emissions (project)
    - Project Case: includes project emission impacts
  - ***Reporting Guidelines*: data collection/retention, controls and measurement systems, record/audit trails**
    - Project Boundaries: defines direct, indirect emissions
    - Source Coverage: GHG emitting source checklist (energy, process, sinks)
    - Changes: Should show differences in emissions resulting from process/technology changes and from accounting changes
  - ***Transparent Record Keeping Processes***

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Options for GHG Inventories

- **GTI's GHGCalc®**
  - Based on GRI/EPA *Methane Emissions from the Natural Gas Industry*, 1996
- **ChevronTexaco's SANGEA™**
  - Based on API *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry*, 2001
- **ICF's GEMS™**
  - Part of ICF's GHGSolutions ™ package
  - Based on primary data for GRI/EPA and other public and published private studies
  - EPA/MMS technical studies/reports

What is a Tier IV Inventory?

- **Tier 1 – national, top down statistics**
- **Tier 2 – industry, broad top down approach**
- **Tier 3 – more detailed industry, sources of emission by facility type, equipment**
  - GRI/EPA 1996 factors used for this and the basis for current approaches
- **Tier 4 – ICF's unique approach based on specific technologies causing emissions within the source**
  - Unbundles data in GRI/EPA 1996 factors and re-bundles by technology and source

Greenhouse Gas Emissions Management System (GEMS™)

- **Not just an inventory – but a tool to help manage economic emission reductions**
  - GRI/EPA Study characterized emission by source
  - ICF GEMS™ characterizes emissions by source and technology
- **Different technologies have different emissions**
  - ICF GEMS™ allows the user to evaluate emissions reduction opportunities by alternative technologies
  - Track inventory results from changes in technology

How is GEMS™ Assembled

- **Excel workbook programs**
  - Inventory Tool
  - Compilation Tool
  - Analytical Tool
  - Back-up evaluation equations/data (proprietary)
    - Continuous Improvement Program
  - Comparison Tool (in development)
  - Configuration Tool (future)
- **ICF configures the program for customer's business sectors**

GEMS™ Inventory Tool

- **Excel workbook distributed to all BUs or facilities (reporting "entities")**
  - Stand-alone, simple user instructions
- **Sources/Technologies configured for User**
- **Choices of Data Input**
  - Recommended Method
    - Customized with field data (including defaults)
  - Simple Method based on industry defaults
  - User Defined

GEMS™ Inventory Tool

Overview | Facility Info | Vented Instructions | Fugitive Inventory | Emissions Summary

GEMS™ Emissions Inventory Workbook
Vented Methane Emissions

Facility/BU Information

Facility Name	Compressor Station 1	Reported By	GEMS Customer
Business Unit	Central	Date	08/15/2003
Reporting Year	2003		

INSTRUCTIONS

To complete the Vented Methane Emissions Reporting Form, follow STEPS 1 to 4 by filling in the requested input data.
Click on the "Vented Instructions" button on top of screen to get more instructions. Detailed information is also provided as comments in respective cells all throughout this worksheet.

GHG Emitting Sources by Operating Sector	STEP 1 Choose Aggregation Level	Aggregation Level	GHG Emitting Technology Category or Process	STEP 2 Insert Activity Data		STEP 3 Choose Default or Insert User-Defined Emission Factor					Annual Emissions			
				Activity Factor	Units	User-Defined	Calculate Default Value	Default Value	Use Default Factor? Check Box if Yes	Units	MMscf/ Yr Methane	Short Tons of CO2e	Metric Tonnes of CO2e	
Transmission Sector														
Gas Dehydrator	● Recommended ● Simple	**Recommended**	**TEG Dehydrator with FTS, with Gas Pump**	1.1	MMscf/d		Get Default	**1.0**	☐	MMscf/ yr per MMscf gas throughput / day	1.1	2.1	2.5	
			TEG Dehydrator with FTS, with Electric Pump	1.0	MMscf/d		Get Default	**1.0**	☐	MMscf/ yr per MMscf gas throughput / day	1	1.9	2.3	
			TEG Dehydrator without FTS, with Gas Pump	0.9	MMscf/d		Get Default	**1.0**	☐	MMscf/ yr per MMscf gas throughput / day	0.9	1.7	2.1	
			TEG Dehydrator without FTS, with Electric Pump	0.9	MMscf/d		Get Default	**1.0**	☐	MMscf/ yr per MMscf gas throughput / day	0.9	1.7	2.1	
			User-defined				Consult							
		Simple	Glycol Dehydrator		# of stations with Glycol Dehydration				☐	MMscf/ station				
Reciprocating Compressor Seals	● Recommended ● Simple	**Recommended**	**Recip Compressor Seals- Vented**	9000	Compressor operating hours	**0.1**	Get Default		☐	MMscf/ compressor hr	0	0.0	0.0	
			User-defined				Consult							
		Simple	Recip Compressor Seals- Vented	20	# of reciprocating compressors			1.0	☐	MMscf/ compressor	20	38.0	45.6	

GEMS™ Inventory Tool: Get Default

GEMS™ Emissions Inventory Workbook
Glycol Dehydrator Recommended E.F. Default Values

Instructions: Either Enter a User-Defined Value for each parameter or Use Defaults (Check Box)

Sector:	Storage	
Dehydrator Type:	TEG DEHYDRATOR WITH FTS, WITH GAS PUMP	
Parameter	User Defined	Default
Glycol Circulation Rate (GPH)		☑ 10
Flash Tank Separator Pressure (PSIA)	800	☐ 100
Is Stripping Gas Used? ☐ (Check box if Stripping Gas Used, Uncheck if Stripping Gas is Not Used.		
Stripping Gas Emission Factor (MMscfy/MMscfd Gas Throughput)		☐ 0.001

OK

GEMS™ Inventory Tool

GEMS™ Emissions Inventory Workbook
Default Values to Estimate Default Emission Factors

DEFAULT VALUES FOR RECOMMENDED EQUATION

Transmission Sector	EF_{OP}	EF_{LV}	EF_{IPP}	EF_{IDP}	Number of Seals
	Mcfh/seal				
Reciprocating Compressors	0.1	N/A	0.1	0.01	1.0
Centrifugal - Dry Seal	0.01	N/A	0.001	0.0001	1.0
Centrifugal - Wet Seal	0.01	0.1	N/A	N/A	1.0

Processing Sector	EF_{OP}	EF_{LV}	EF_{IPP}	EF_{IDP}	Number of Seals
	Mcfh/seal				
Reciprocating Compressors	0.01	N/A	0.1	0.01	1.0
Centrifugal - Dry Seal	0.01	N/A	0.001	0.0001	1.0
Centrifugal - Wet Seal	0.01	0.1	N/A	N/A	1.0

Gathering/Booster Sector	EF_{OP}	EF_{LV}	EF_{IPP}	EF_{IDP}	Number of Seals
	Mcfh/seal				
Reciprocating Compressors	0.01	N/A	0.1	0.01	1.0
Centrifugal - Dry Seal	0.01	N/A	0.001	0.0001	1.0
Centrifugal - Wet Seal	0.01	0.1	N/A	N/A	1.0

Storage Sector	EF_{OP}	EF_{LV}	EF_{IPP}	EF_{IDP}	Number of Seals
	Mcfh/seal				
Reciprocating Compressors	0.01	N/A	0.01	0.01	1.0
Centrifugal - Dry Seal	0.001	N/A	0.001	0.0001	1.0
Centrifugal - Wet Seal	0.01	0.1	N/A	N/A	1.0

GEMS™ Compilation Tool

- **Master Excel Workbook**
  - Electronically compiles all inventories
  - Management report on inventories received
  - Exception report on missing inventories
  - Eleven sort options
    - Company-wide
    - BUs
    - Etc
- **Output Reports**
  - Tables, bar charts, pie charts
  - Methane emissions and CO_2 Equivalent

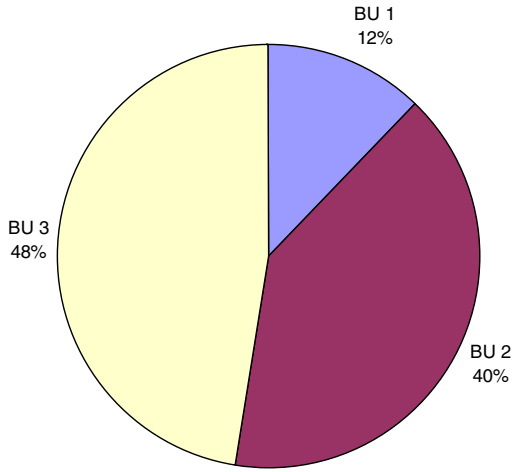
GEMS™ Compilation Tool

GEMS™ Emissions Management Workbook
GHG Emissions Inventory Summary by Business Unit

Summary Table and Emissions Pie Chart

Business Unit	Fugitive Emissions			Vented Emissions			Total Emissions		
	Methane Emissions MMscf/yr	Short Tons of CO2e	Metric Tonnes of CO2e	Methane Emissions MMscf/yr	Short Tons of CO2e	Metric Tonnes of CO2e	Methane Emissions MMscf/yr		Metric Tonnes of CO2e
BU 1	13,033	5,282,275	4,754,047	11,632	4,714,450	4,243,005	24,665	9,996,725	8,997,052
BU 2	17,190	6,967,107	6,270,396	63,674	25,807,072	23,226,365	80,864	32,774,179	29,496,761
BU 3	64,898	26,303,159	23,672,843	30,757	12,465,812	11,219,231	95,655	38,768,972	34,892,074
Total	95,121	38,552,541	34,697,287	106,063	42,987,334	38,688,601	201,184	81,539,875	73,385,888

Total Emissions by Business Unit



GEMS™ Analytical Tool

- **Main Feature in Source/Technology Sort**
  - Drop-down menus with lower emission alternatives
- **Global settings**
  - Price of natural gas (can be zero)
  - Value of carbon market credits (can be zero)
  - Capital/O&M cost indices (to update costs)
  - Discount rate for economics
  - Choices of units (e.g. metric tonnes CO_2E)
- **Evaluates potential emission reductions and economics**

GEMS™ Analytical Tool Output

- **Reports values of alternative(s) for inventories compiled**
- **Emissions reductions**
  - Methane, CO_2E
- **Costs**
  - Capital and O&M (tied to cost indices)
- **Economics**
  - Positive economics: NPV, IRR, payback
  - Negative economics: break-even carbon credit

GEMS™ Analytical Tool Output
Global Setting for Economics

GEMS™ Emissions Management Workbook
Vented Emissions Reduction Potential Through Technology Upgrades

Global Parameters		
Price of Gas	$/ Mcf	$ 3.00
Value of each Carbon Credit	$/Metric Tonne	$ 2.00
Discount Factor for NPV Calculations	%	10%
Cost Indices for the Current Year		
Cost Index for New Equipment		1264.6
Cost Index for Operating Costs		448.2

Select Units
- ● $/Metric Tonne CO2e
- ● $/Short Ton CO2e

GEMS™ Analytical Tool Output Drop-down Menu of Choices

GHG Emitting Sources by Operating Sector	GHG Emitting Technology Category or Process	Activity Factor		Total Emissions	Alternative Technologies or Practices	Calculate Savings
		Total Activity Factor	Units	MMscf / Yr Methane		
Gathering/Boosting Sector						
Gas Dehydrator	TEG Dehydrator with FTS, with Gas Pump	20	MMscf/d	10.00	Replace Gas Pump with Electric Pump	Calculate
	TEG Dehydrator with FTS, with Electric Pump	1.1	MMscf/d	1.00	Replace with Desiccant Dehydrator	Calculate
	TEG Dehydrator without FTS, with Gas Pump	1.1	MMscf/d	1.00	No Change	Calculate
	TEG Dehydrator without FTS, with Electric Pump	1.1	MMscf/d	1.00		Calculate

Replace with Desiccant Dehydrator
Replace Gas Pump with Electric Pump
Install Flash Tank
Install Flash Tank and Replace Gas Pump with Electric Pump

GEMS™ Analytical Tool Output
Economic Output

Number of New Technology Units Required	Emissions Reduction		Net First Year Cost $	Net Annual Savings (Cost) $/yr	Net Present Value $	IRR %	Payback Period (years)	Breakeven Value for Carbon Credit $/Credit	Comments / Conditions
	MMscf/yr Methane	Carbon Credits Gained							
3	0.79	320	9,313.64	2,092.74	-1,255.03	0.04	4.45	3.14	
7	4.54	1,838	265,380.57	-192,232.87	-903,722.18	No Returns	No Payback	144.65	
1	0.66	266	3,104.55	2,199.72	4,758.28	0.65	1.41	-3.19	
0	-	0	0.00	0.00	0.00				

Bases for GEMS™ Analyses

- **Public Information**
  - GRI/EPA and MMS published emissions data
  - Gas STAR Lessons Learned Studies and Partner Reported Opportunity Fact Sheets
  - Industry conference published proceedings
  - Technical studies, reports, briefs
- **Private Sector published studies/reports**
  - API Compendium
  - Vendors' data
- **Continuous improvement plan to update technologies/practices, economics**

Background on ICF Consulting

ICF Consulting

- **Founded 1969;** now has 1000+ Employees
- **Offices:** Canada, Asia, Brazil, Russia, UK, and throughout the United States
- **Core Business Units:** Energy, economics, emergency management, environment, housing, and IT services:
- **Energy Practices:** Natural Gas and Oil, Power, Emissions Markets, Coal, Energy Efficiency, Risk Analysis, Billing Systems

ICF's GHG Practice

- **World's largest with over 200 staff**
- **Over 15 years experience in GHG issues**
- **Expertise in over 120 countries**
- **In-depth expertise in U.S. gas and oil sector**
- **Greatest technical depth**
  - Planning, Inventory, Protocols
  - Monitoring, Verification
  - Mitigation, Valuation, & Management
  - Software tools

ICF Pioneered GHG Analysis

EMISSION INVENTORY & PROTOCOLS

- **Corporate-wide GHG protocols for major oil/gas, cement, forest products, mining and metallurgical clients in Canada, UK, and US**
  - British Petroleum GHG inventory, protocols, audits
  - Six official World Resources Institute/World Bank Corporate GHG Protocols
  - 21 web-based GHG industry protocols for International Finance Corporation
- **National GHG Inventory Methodologies (1990-Present)**
- **Official U.S. GHG Inventory Submission to the United Nations (1990-Present)**
  - Annual natural gas and oil industry methane inventory

ICF Pioneered GHG Analysis

EMISSION VALUATION, MONITORING & VERIFICATION

- **Energy Industry GHG Marginal Abatement Cost (MAC) Curves used by EPA, trade groups, and IPCC**
  - Developed first marginal abatement cost curves for the gas sector
- **Environment Canada's Entity Level Reporting analysis and Issues Tables**
- **Internal Trading system for Canadian global company**
- **GHG emissions Monitoring and Verification Plan (MVP) for World Bank's $150M Prototype Carbon Fund**
- **EPA's prime contractor for the Natural Gas STAR Program inventory and mitigation**

For Further Information

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