QUANTIFICATION PROTOCOL FOR INSTRUMENT GAS TO INSTRUMENT AIR CONVERSION IN PROCESS CONTROL SYSTEMS

2nd Stage Review of GHG Quantification Protocols

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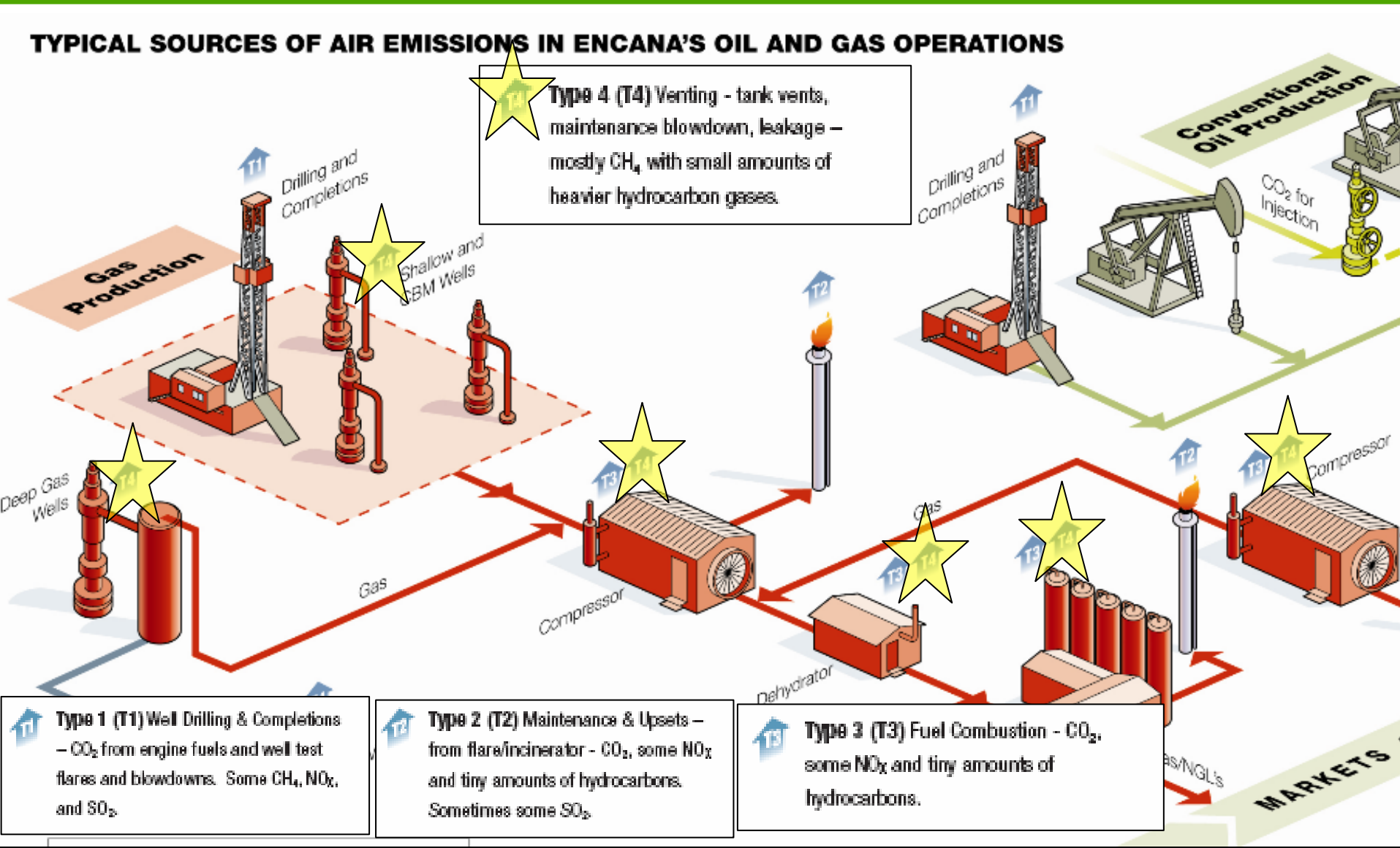
Sutton Place Hotel | Edmonton | December 28, 2008

Introduction



Process Overview

- **Step 1 Alberta Protocol Development Process Seed material/key references**
  - Reviewed existing protocols/methodologies
  - US EPA Gas Star Program
  - Instrument Society of America (ISA) Standard
  - ISO 14064 Part 2
  - Industry experts
- **No directly related protocols available, but some good guidance documents were found**
- **Developed proposed protocol**

Process Overview

- **Developed TPP and TSD in support of protocol**
- **Expert Technical Review**
  - **Step 7-** Alberta Protocol Development Process
  - Held on November 3rd, 2008
  - Internal/External reviewers-10
    - Industry- BP, EnCana, Petro-Canada
    - Technology providers- Spartan Controls
    - Government- ARC, Climate Change Central
    - Academia- University of Calgary
- **No sustained objections to move forward**
- **Updated protocol with comments from review and feedback submitted one week later.**

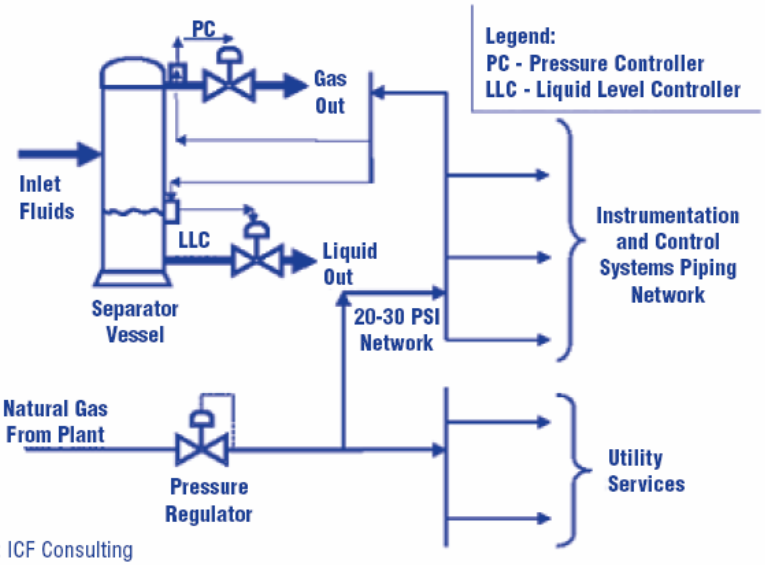
Project and Baseline Condition

- **Project Condition**
  - Defined as volume of compressed air used to power pneumatic devices.
  - Compressed air will also need management.
- **Baseline Condition**
  - Defined as the volume of natural gas vented, or flared/combusted to the atmosphere prior to the conversion to the air system.
  - This gas is typically sourced from the fuel supply for the entire facility.
- **<u>Note: Vented gas will be completed eliminated</u>**

Project and Baseline Condition

Baseline

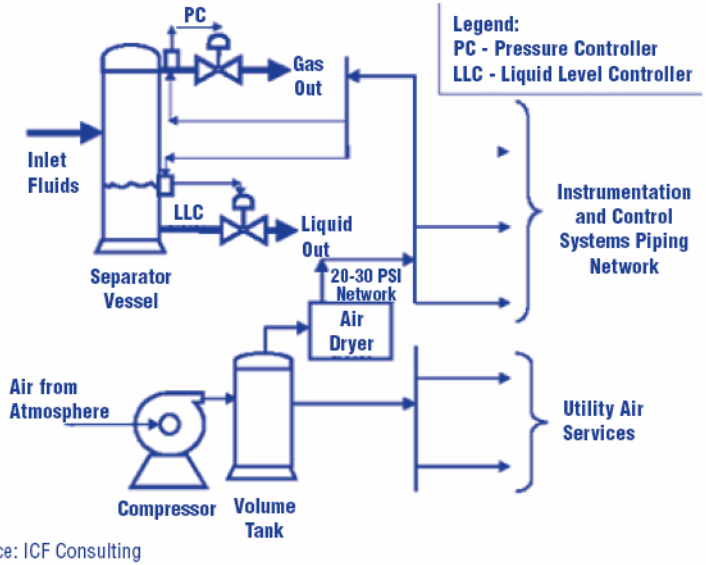
Exhibit 1: Natural Gas Pneumatic Control System



Source: ICF Consulting

Project

Exhibit 3: Compressed Instrument Air System



Source: ICF Consulting

Source: US EPA Natural Gas STAR Program (2004). “Lessons Learned- Convert Gas Pneumatic Controls to Instrument Air”

Basis For Reduction

- **Functional Equivalence**
  - Same pressure, different volumes due to nature of gases
  - Metric is volumes of air and gas
  - Multiplied by density, then mass is also metric
- **Emissions reduction are REAL**
  - Elimination of vented or flared/combusted gas
- **Account emissions from air compression and management**
- **Fuel extraction and processing**

Emissions Comparison

- **As stated before same volume but different pressure**
- **Need to compare baseline - project emissions**
- **Used ISA *ANSI/ISA-75.02-1996 Control Valve Capacity Test Procedures* Standard**
  - Made assumptions
- **Incorporated gas equivalency formula into protocol**

$$Q_{CH4} = 1.2994 * Q_{AIR}$$

Applicability Criteria

- **Demonstrate functional equivalence- instrument air will replace instrument gas**
- **Project proponent to inspect and repair leaks prior to actual metering to reduce and mitigate risks associated with overestimation of emissions or use discount factors.**
- **Use section 8.7 in Directive 60-CAPP *Best Management Practice (BMP) for Fugitive Emissions Management* to minimize leaks**
- **Instrumentation or Chemical Injection Pumps (CIP), or other types of equipment.**
- **The project must meet Alberta Offset System requirements.**

Flexibility Mechanisms

- Site specific emissions factors may be substituted for generic emission factors (i.e. electricity displacement factor)
- Baseline and project metering may be carried out for more than one month
- Retroactive crediting for unmetered ongoing projects
- Vented and flared/combusted gas streams
- Adjustment to baseline by adding or decommissioning of devices
- Instrument air conversions can be installed at single or multiple sites-aggregating small projects

Baseline LCA Analysis-SSs

Upstream SS's During Baseline

- B 1 Raw Gas Production
- B 2 Raw Gas Transportation
- B 3 Raw Gas Processing
- B 5 Fuel Gas for Facility Processes
- B 6 Instrument Control Process
- B 9 Electricity Usage
- B 10 Fuel Extraction/ Processing
- B 11 Fuel Delivery

Upstream SS's Before Baseline

- B 12 Construction on Site
- B 13 Development of Site
- B 14 Building Equipment
- B 15 Transportation of Equipment
- B 16 Testing of Equipment

On Site SS's During Baseline

- B 7 Vented Fuel Gas
- B 8 Flared/ Combusted Fuel Gas

Downstream SS's After Baseline

- B 17 Site Decommissioning

Downstream SS's During Baseline

- B 4 Processed Gas Distribution and Sale

Project LCA Analysis-SSs

Upstream SS's During Project

- P 1 Raw Gas Production
- P 2 Raw Gas Transportation
- P 3 Raw Gas Processing
- P 5 Fuel Gas for Facility Processes
- P 8 Electricity Usage
- P 9 Fuel Extraction/ Processing
- P 10 Fuel Delivery

Upstream SS's Before Project

- P 11 Construction on Site
- P 12 Development of Site
- P 13 Building Equipment
- P 14 Transportation of Equipment
- P 15 Testing of Equipment

On Site SS's During Project

- P 6 Air Compression
- P 7 Air Management System

Downstream SS's After Project

- P 16 Site Decommissioning

Downstream SS's During Project

- P 4 Processed Gas Distribution and Sale

Quantification Approach

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Vented Fuel Gas}} + \text{Emissions}_{\text{Flared/Combusted Fuel Gas}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Air Compression}} + \text{Emissions}_{\text{Air Management System}}$$

- **Key data to be metered (from one month metering as per protocol approach):**
  - Compressed air volumes
  - Electricity for compressor and air management
- **Gases included: CH_4, CO_2, N_2O**

GHG Reduction-Wilson Creek

Baseline Emissions	
Vented Gas (46,356 m^3/yr or air)	**858.4 tCO_2e**
Fuel Extraction/Processing	**11.5 tCO_2e**
Flared/Combusted	**-**
Total	**869.9 tCO_2e**
Project Emissions	
Air Compression (34,164 kWh/yr)	**22.2 tCO_2e**
Air Management (2,978 kWh/yr)	**1.94 tCO_2e**
Total	**24.14 tCO_2e**
Offsets	**845.7 tCO_2e**

Thank you for your attention

Questions and suggestions

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Background

Approach- need to compare baseline and project emissions

- **The capacity of a device to flow air or gas is expressed in terms of C_V, or flow coefficient. Measures the impact on flow from diverse factors to a device such as:**
  - Orifice size (diameter of the piping or opening through the valve);
  - Length of piping or opening through the valve;
  - Turbulence caused by bends or turns in the piping;
  - Restrictions, or anything that reduces the orifice size or the flow path; and
  - Shape of the orifice.

Approach- need to compare baseline and project emissions

- **Assume natural gas and air have same energy loss, so substitute C_v for air into (1)**

$$Q_{CH4} = Q_{AIR} * \frac{1}{\sqrt{\frac{1}{G_{AIR}}}} * \frac{1}{Y_{AIR}} * Y_{CH4} * \sqrt{\frac{1}{G_{CH4}}}$$

- **Substituting terms**

$$Q_{CH4} = Q_{AIR} * \sqrt{\frac{G_{AIR}}{G_{CH4}}} * \frac{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/k_{CH4})\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)} * x_T}{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)} * x_T}$$

- **k=specific heat of gas; G=specific gravity of gas; β= orifice to pipe diameter ration**

Equations to quantify emissions

- **CH_4**

$$Q_{CH4} = Q_{AIR} * \sqrt{\frac{G_{AIR}}{G_{CH4}}} * \frac{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/k_{CH4})\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)*x_T}}{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)*x_T}} * \%CH_4 * \rho_{CH4}$$

- **CO_2**

$$Q_{CH4} = Q_{AIR} * \sqrt{\frac{G_{AIR}}{G_{CH4}}} * \frac{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/k_{CH4})\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)*x_T}}{1 - \frac{x}{\left(\frac{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}{\left(1-(0.41+0.35*\beta^4)*(x/1.4)\right)}\right)*x_T}} * \%CH_4 * \rho_{CH4} * \frac{\%CO_2}{\%CH_4} * \frac{44}{16}$$