HANDBOOK FOR REVIEW OF NATIONAL GHG INVENTORIES

CHAPTER III: ENERGY SECTOR ISSUES

1. This chapter provides specific guidance to assist in the review of the estimation of emissions of the energy sector. The guidance is for use by experts during an annual technical review. The overall aim is to help review experts in performing their tasks, avoid duplication of efforts, and promote consistency in the different types of reviews of national greenhouse gas (GHG) inventories (desk, centralized and in-country review teams) for the technical review of GHG inventories.

2. The guidance presented in this document for the review of emissions is independent of which review approach is taken (i.e., desk, centralized or in-country).

3. The guidance presented in the tables in this handbook is not intended as a checklist where the team must complete all the questions but rather as reference manual for the reviewers. Each of the tables and to a large extent the questions may be used independently. Questions relevant for checking cross cutting issues like choice of Tier, uncertainty and QA/QC are provided once in the Chapter III general review tables.

Fuel Combustion – Energy Industries (Section 1.A)

General Issues

4. Fuel Carbon and Energy Content: There is considerable variation in the energy and carbon content by weight of fuels. However, expressing the carbon emission factors as the carbon content per unit of energy released reduces this variation because of the close link between the carbon content and the energy value of the fuel. It is natural therefore that all fuel supply and consumption data for combustion emission calculations be expressed in energy units. Energy data expressed in other units should be converted to terajoules (TJ) before use.

5. Fuel consumption: While the IPCC Guidelines recommend using NCV to convert the AD (energy consumption) into energy units for the estimation of GHG emissions, the CRF allows Parties to report fuel consumption in energy units based on net calorific values (NCV) or gross calorific values (GCV). For Parties that report using GCV, the IEFs for energy consumption will seem unusually low compared to those of other Parties that report using NCV, and a straightforward comparison of IEFs across all Parties is therefore difficult. If available, the conversion factors used to convert data based on GCV to NCV can be used to calculate NCV-based IEFS for these Parties.

6. Unoxidised Carbon: When energy is consumed not all of the carbon in the fuel oxidises to CO_2. Incomplete oxidation occurs due to inefficiencies in the combustion process that leave some of the carbon unburned or partly oxidised as soot or ash.

7. Stored Carbon: Some of the fuel supplied to an economy is used as a raw material (or feedstock) for manufacture of products such as plastics, fertilisers, or in a non-energy use (e.g., bitumen for road construction, lubricants). In some cases, the carbon from the fuels is oxidised quickly to CO_2. In other cases the carbon is stored (or sequestered) in the product, sometimes for as long as centuries. The amounts stored for long periods are called stored carbon, and should be deducted from the carbon emissions calculation. Estimation of stored carbon requires data on fuel used as feedstock and/or quantities of non-energy fuel products produced. The calculations are discussed within each of the alternative approaches presented in this section.

8. Bunker Fuels: The Intergovernmental Panel on Climate Change (IPCC) methodology subtracts the quantities delivered to and consumed by ships or aircraft for international transport from the fuel supply to the country. In this manner, the CO_2 emissions arising from

the use of international bunkers are not included in the national total. To simplify the preparation of global estimates, these emissions should be brought together in a separate table.

9. Biomass Fuels: Biomass fuels are included in the national energy balance and emissions accounts for completeness. These emissions should not be included in national CO_2 emissions from fuel combustion. If energy use, or any other factor, is causing a long-term decline in the total carbon embodied in standing biomass (e.g., forests), this net release of carbon should be evident in the calculation of CO_2 emissions described in the *Land Use, Land-Use Change and Forestry* chapter.

10. For some of the large combustion plants in European industries (electricity generation, iron and steel manufacturing, and oil refining in particular), sources of information on processes and emission factors for CH_4 and N_2O are included in the "Best Practice Reference Handbooks"[1]. Reviewers may find this information useful to consult prior to conducting the review.

[1] http://eippcb.jrc.es/pages/Fmembers.htm

Table 1.A.1.a: Public Electricity and Heat Production

Source Category	1.A.1.a Public Electricity and Heat Production - Overview		
Definition	Comprises electricity-only plants, combined heat and power plants, and heat-only plants. Public utilities are undertakings whose primary activity is to supply electricity to the public. They may be publicly or privately owned. Emissions from the on-site use of fuel should be included.		
Potential Key Issues:	Emission factors should be appropriate for the qualities of fuels used and combustion conditions, as small errors can have large effects on emissions. Issues of possible omission or misallocation at the margin may arise from the inclusion of only plants above a certain size, or from the inclusion of plants which are technically autogenerators[2] but which sell all of their output into the public electricity grid. Proper emission calculations employ an adjustment (the assumed fraction of carbon oxidised) to account for residual carbon that is not combusted, and thus remains in solid form in slag, particulates, soot or ash. Use of IPCC default oxidation factors provides for consistent emission estimates, but the use of country-specific oxidation factors may improve the accuracy. Country-specific oxidation factors reflect differences in boiler technology and maintenance; more advanced and/or well-maintained boilers will have higher oxidation rates.		
General References	IPCC good practice guidance, Chapter 2.1.3 IPCC Guidelines – Reference Manual (Volume 3, Chapter 1.7, pages 1.99 to 1.113)		
Source Category		**1.A.1.a Public Electricity and Heat Production - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	If emissions have not been estimated based on fuel *consumption* at power stations, then what steps would be required to adopt this basis?	The quality of power station fuels will often differ from fuels of the same type in use in other sectors. The accuracy of emission estimates may be improved through the use of specific plant-based fuel composition data.
	CH_4, N_2O	Which estimation method has been used, and does it reflect the variety of fuel types used and the boiler combustion conditions? If not, what are the impediments to developing a better method?	Direct measurement of emissions is permitted. The importance of this source argues in favor of the greatest possible degree of disaggregation.
Emission Factor	CO_2	How have emission factors been obtained for fuels used specifically for electricity and heat generation? Are specific factors used for fuels burned to initiate combustion during "start up" conditions? Are appropriate factors used for unusual fuels? Are the factors plant-specific (for solid fuels, in particular)? How have the emission factors for waste and unconventional fuels been derived?	The qualities of coal and oil used at power plants may differ from those used in other industrial plants. Some plants may also experiment with unusual fuels, e.g., orimulsion, petroleum coke or waste oils. Country-specific oxidation factors reflect differences in boiler technology and maintenance. Some countries may be using carbon recovery from ash. If the sources of fuel supply or

[2] Autogenerators, or autoproducers, are undertakings which generate electricity or heat wholly or partly for their own use, as an activity which supports their primary activity. Emissions from autoproducers should be assigned to the sector in which they were generated, and not under 1.A.1.a, (Public Electricity and Heat Production).

		What is the basis for adjustments for incomplete oxidation? Is it plant-specific? When were the emission factors last reviewed?	qualities of fuel have changed over time, the applicability and accuracy of the emission factors must be confirmed
Activity Data Stationary Combustion	All gases	Do the data come directly from the plants, or are they based on fuel deliveries? If based on deliveries, are all direct imports of fuels by power stations included? What are the impediments to collecting and using fuel combustion data? Are all fuels used included? In particular, are biofuels identified? How are data for waste or other unconventional fuels obtained? If a Tier 2 method is used, are total quantities of fuels consumed checked against declared deliveries to the source category?	If a plant uses unconventional or unusual fuels (e.g., orimulsion), issues of confidentiality may arise, which may in turn lead to the plant's omission from the source category. Emissions from biofuels require separate identification, as they are excluded from national CO_2 totals but included in totals for other gases.
Mobile sources	All gases	Have estimates for emissions from on-site transport been included? If not, where have they been included?	Emissions related to mobile sources should be reported under sourcce category 1.A.3 in CRF Table 1.A(a).
Completeness	All gases	What checks are employed to ensure that all power stations have been included? Describe any limitations on data collection which may affect the completeness of this source category.	Small power stations may be excluded from the data to limit collection costs. Some plants which generate electricity as a secondary activity may be incorrectly included here instead of in the source category based on their primary activity.
Recalculations/ Consistent time series	All gases	How are changes in fuel qualities and combustion conditions monitored and incorporated into the emission estimates? What mechanism has been used to identify revisions to past activity data? What recent recalculations have been made?	The accuracy and consistency of the time series will depend upon the mechanisms used to account for changes in fuel qualities and combustion conditions, and therefore changes in emission factors and activity data. Ideally, the process should include authoritative sources for emission factors and close contact with data providers.
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.1.b: Petroleum Refining

Source Category	1.A.1.b Petroleum Refining - Overview		
Definition	Includes all combustion activities supporting the refining of petroleum products. Evaporative emissions are not included in this category.		
Potential Key Issues:	The manufacture and refining of petrochemicals are closely related activities often conducted at the same facility. Some refineries may not be able to fully separate the fuel used in the refinery from that consumed in the petrochemical industry.		
General References	IPCC good practice guidance 2.1.3		
Source Category		**1.A.1.b Petroleum Refining - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	What methods are used to estimate emissions from refineries? If direct methods are not used, what are the reasons and what method is used?	Direct estimation is preferred using refinery fuel consumption data and the associated emission factors. In cases where consumption data are incomplete or unavailable (perhaps due to confidentiality issues), indirect methods such as refinery capacity may be used.
	CH_4, N_2O	What methods are used for estimation of emissions from refineries? If direct methods have not been used, an explanation for this and a description of the method chosen should be provided.	Emissions may be calculated in a manner similar to that used for CO_2, or with data and emission factors related to the specific process and plant in the national refineries. This is the preferred alternative, but in many countries the necessary data may not be available.
Emission Factor	CO_2	What are the sources of the emission factors (and calorific values, if used) for the refinery fuels? This is particularly important with respect to refinery gas, fuel oils and residues, as the composition of these fuels may vary. Does the emission factor for refinery gas relate to the combusted gas? Have there been changes in pollution controls? What has been the effect on emission factors?	Emission factors for CO_2 from fossil fuel combustion are best expressed on a per unit energy basis because the carbon content of fuels is generally less variable when expressed on a per unit energy basis than when expressed on a per unit mass basis (See IPCC good practice guidance 2.1.1.2). Refinery gas as combusted may differ in composition from refinery gas as produced, because some useful chemicals may be removed before combustion. Installation or removal of controls for non-CO_2 gases may cause decreases in operating efficiency, leading in turn to a higher emission factor for CO_2.

	CH_4, N_2O	What are the sources of the emission factors for these gases, and to what extent are they able to discriminate between different processes?	Check the sources of the emission factors, as these factors are process-specific e.g., distillation columns and burning off petroleum coke. Appropriate emission factors should also be used for waste fuels used for on-site power generation.
Activity Data Stationary Combustion	All gases	What are the sources of data used to estimate emissions? How are the activity data measured? Does the refinery use waste or unclassified fuels? If so, how are consumption data obtained? What steps are taken to ensure that emissions from purchased fuels (for example, natural gas) are included? What steps are taken to ensure fuels used in co-located petrochemical sites are excluded?	Two of the major fuels used in refineries are refinery gas and petroleum coke. The quantities of these fuels consumed may be expressed in a variety of units, which may not be the units in which they were originally measured. It is important to know what method has been used to derive the reported estimates. If a detailed analysis of emissions from the main parts of a refinery plant is available, this should suffice for estimation of all gases.
Completeness	All gases	What checks are made on carbon completeness in refineries? If there are integrated refining and petrochemical facilities, what steps have been taken to ensure that double counting or omission of emissions has not occurred in these source categories?	Mass and carbon mass balance checks may be made on refinery carbon emissions if reliable carbon content factors are available for the crude oil and other feedstocks entering the refinery. This will include evaporative emissions of non-methane hydrocarbons. If there are wide differences between the balances of mass and carbon, the carbon content factors should be considered suspect.
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.1.c: Manufacture of Solid Fuels and Other Energy Industries

Source Category	1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Overview
Definition	This source category includes the following: • Manufacture of solid fuels - emissions from fuel combustion for the production of coke, brown coal briquettes and patent fuel. • Other energy industries - emissions from the energy industries' own, on-site fuel combustion not already covered in 1A1.a and 1A1.b. The energy industries include coal, oil and gas extraction activities. Combustion emissions from pipeline transport of fluids should be reported under 1.A.3.
Potential Key Issues:	The definition does not contain a complete list of energy industries that should be included in this source category. Consequently, there is a risk of omission. For example fuel combustion emissions from the reprocessing of nuclear fuel should be included here, but may in fact be excluded in some cases given the categorsation of nuclear plants. Misreporting may also occur when emissions arise from solid fuel/gas manufacture in iron and steel manufacturing.
General References	IPCC good practice guidance (GPG) 2.1.3. The recommendations for carbon balance checks are particularly relevant for coke ovens.

Source Category		1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	What are the major sources in this category, and what methodologies have been used to estimate emissions from them? How have the fuel combustion emissions from coke ovens been separated from fugitive emissions? If fugitive emissions are estimated as the residual losses of carbon in an analysis of carbon flow through coke ovens, what checks have been made on the carbon contents of the inputs and outputs?	The source category covers many different activities, some of which may not have adequate activity data. The report should concentrate on the key sources. It is important to clarify how fuel combustion emissions are distinguished from fugitive emissions.
	CH_4, N_2O	What are the major sources in this category, and what methodologies have been used to estimate emissions from them? How has the estimation of emissions from locally extracted fuels (e.g., colliery methane and unrefined gases) been done?	The source category contains very different types of combustion plants, many of which will often use locally available fuels that may not be suitable for sale. Examples are found in the coal, oil and natural gas extraction industries.
Emission Factor	CO_2	What checks have been made on the accuracy and origin of the emission factors? Have emission factors or	Some of the fuels used in this source category will not be purchased fuels, and will have calorific values and carbon contents which are determined by local fuel availability. Where the quantity of local fuel used

		carbon contents been used in carbon flow analysis of coke ovens?	is significant (for example, in the case of unrefined gases) it will be important to assess the origins of the emission factors.
		In plants where the use of locally extracted fuels is significant, how have the emission factors for locally extracted fuels been obtained, and how are they derived?	Carbon flow analysis (carbon balances) for coke ovens should use emission factors without adjustment for incomplete oxidation (carbon content). Natural gas frequently contains unacceptable levels of moisture, heavy hydrocarbons (ethane, propane and butane are the liquids with economic value, extracted at a natural gas processing plant, but other petroleum gases, such as isobutane, pentanes, and natural gasoline are also processed. At some point during the processing-to-pipeline specifications, these components must be removed and treated, i.e. cleaned, before it can be safely delivered to the high-pressure, long-distance pipelines. Natural gas that is not within certain specific gravities, pressures, calorific value range or water content levels will cause operational problems, pipeline deterioration, or can even cause pipeline rupture. The composition of the raw natural gas extracted from producing wells depends on the type, depth and location of the underground deposit and the geology of the area, and in few cases pipeline-quality natural gas is actually produced at the wellhead or field facility. For the above-described reasons, raw gas commonly is not used in upstream facilities, such as separation/processing plants. Moreover, every single separation plant in a country could produce "dry" natural gas with different energy contents or "pipeline-qualities" to meet different delivery contracts and standards which vary from pipeline to pipeline and are usually a function of a pipeline system's design, its downstream interconnecting pipelines, and its customer base. This information indicates that the gas EF used in this category requires

			careful assessment.

Emission Factor	CH_4, N_2O	What checks have been made on the accuracy and origin of the emission factors? In plants where the use of locally extracted fuels is significant, how have the emission factors for these fuels been obtained, and how are they derived? If there are industry studies of emissions from sources in this category, have they been properly referenced?	Emission factors will vary according to plant type. For key sources, check that consultation with industry representatives has taken place.
Activity Data Stationary Combustion	CO_2	How have the data been obtained from the main sources? If obtained indirectly, what checks have been applied to the quality?	If this source category is a key source or major contributor to the fuel combustion CO_2 data obtained indirectly (e.g., through trade associations or energy data collection systems) should not be accepted automatically. The assessment of the quality of indirect data also requires a good understanding of the underlying processes. Energy data for coke oven inputs and outputs should be subject to energy balance checks.
	CH_4, N_2O	Have detailed data from large plants been used? Do they include unconventional or non-marketable fuels? Have CH_4 emissions from coal mining gas recovery been divided between fuel combustion and fugitive emissions?	It is unlikely that fuel combustion data for these diverse activities will be disaggregated to an extent which will permit a full application of Tier 2 methods. However, some large plants such as coke ovens may have adequate data; if so, check that it has been used for the emission estimates.
Mobile sources	All gases	Are there emissions from the transport of fuels, goods or persons "off-site" which are included here and not under transport?	Integrated steel works may be very large and require on-site transport.
Non-energy use	All gases	How are emissions from tars and oils from coke manufacture reported? If there is non-energy use of any of the hydrocarbons obtained from these activities, are any related fuel combustion emissions from their use reported in industrial processes?	Tars, oils and extracted gases may be used for on-site heating, or for petrochemical feedstock.
Completeness	All gases	Are all "other" energy industries included? Are there energy industries in which the fuel combustion data are weak	For example: Gas liquefaction plants Oil shale extraction and shale oil treatment Nuclear fuel reprocessing Manufacture of liquid and gaseous

		or not available? What fraction of the total emissions from 1.A.1.c are they estimated to represent? If estimates are used, how are they made?	fuels from "in-situ" primary fuels
Recalculations/ Consistent time series	All gases	Which activity data have been estimated, and have similar estimating procedures been used over the inventory period?	Discontinuities in activity data are not uncommon, particularly when inventories extend back over a period of ten years or more. See GPG 7.3.2 for additional guidance.
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.2.a: Iron and Steel

Source Category	1.A.2.a Iron and Steel - Overview
Definition	Iron and steel manufacturing as covered by International Standard Industrial Classification of All Economic Activities (ISIC) Group 271 (Manufacture of basic iron and steel) and Class 2731 (Casting of iron and steel), and the General Industrial Classification of Economic Activities within the European Communities (NACE) 27.1 (Manufacture of basic iron and steel and of ferro-alloys (ECSC)*) through 27.3 (Other first processing of iron and steel and production of non-ECSC* ferro-alloys), 27.51 (Casting of iron), and 27.52 (Casting of steel). Emissions from fuel combustion at coke ovens should be reported undersource category 1.A.1.c.
Potential Key Issues:	The source category covers integrated steelworks, separate manufacture of steel products and ferrous metal foundries. If foundries treating ferrous and non-ferrous metals exist on the same site, separate data for both processes will be required. It is difficult to distinguish correctly between emissions from fuel combustion, fugitive sources and industrial processes. IPCC good practice guidance largely updates the IPCC Guidelines in providing advice on the separation of these sectors.
General References	IPCC good practice guidance (GPG) 2.1.1.4, GPG 3.1.3

Source Category		1.A.2.a Iron and Steel - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Describe the methodology for estimating emissions from fuels used in this source category, identifying how: a) emissions from blast furnaces are estimated and reported. b) emissions have been divided, in cases where blast furnace emissions are divided between fuel combustion and industrial processes. c) emissions from fuels injected into blast air are included. d) any emissions from basic oxygen steel furnaces are estimated and reported. e) how emissions from any limestone in blast furnaces are estimated and reported (note that in some countries, lime is used instead of limestone). When limestone is used, its carbon emissions will be contained in the blast furnace gas, so double counting with source category 2.A.3, Limestone and Dolomite Use, should be avoided. f) emissions from fuel use in processing iron and steel are included.	Emissions from the iron and steel industry arise from blast furnaces, basic oxygen furnaces, metal processing and power generation activities. The GPG advocates but does not require reporting emissions from iron and steel making in the industrial process sector. Emissions may therefore be divided between fuel combustion, categories 1.A.1c and 1.A.2.a, and industrial processes, categories 2.A.3 and 2.C.1. If the GPG recommendation is followed, all fuel combustion emissions from blast furnace gas and any reductants must be set to zero. Where iron and steel manufacture is an important activity in the country, the emission methodologies should be able to divide emissions between these source categories. However, in light of the complex nature of accounting for emissions at blast furnaces, the review should focus on ensuring that there is no duplication or omission of emissions rather than precise source categorisation. In countries with a significant iron and steel industry, this source category requires a Tier 2 methodology.
	CH_4, N_2O	Are non-CO_2 gases included in the estimates?	The IPCC Guidelines and GPG suggest negligible emissions of these gases from fuel combustion in this source category.
Emission Factor	CO_2	What are the sources of emission factor information for coking coals, other coals and petroleum cokes, tars and oils, coke oven gas and blast furnace gas? What analyses do they depend on? What checks of their validity have been made?	Emission factors and calorific values for fuels used in and produced by iron and steel activities need careful examination, because some fuels are different from similar fuels used in other industries. Data for all fuels are required even if the fuel is involved only in industrial process emissions, because carbon flow analyses should be conducted to check activity data and emission factors.

Source Category		1.A.2.a Iron and Steel - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Activity Data Stationary Combustion	All gases	What are the sources of data for fuel consumption in the iron and steel industry? Are any fuels omitted (e.g., tars and oils)? Does data for fuel carbon entering and leaving blast furnaces and the uses of blast furnace gas exist? Can all fuels used to heat blast air be identified and quantified? Do the reported quantities of blast furnace gas contain basic oxygen furnace gas? If so, is this taken into account in source category 2.C.1?	Some of the questions relating to data for blast furnaces may not bear directly on the estimation of fuel combustion emissions, particularly if the GPG recommendation to place all blast furnace and basic oxygen furnace (BOF) emissions in source category 2.C.1 is followed. However, since energy data are used in the estimation process for the source category 2.C.1, the questions should be presented to qualified fuel combustion experts.
Completeness	All gases	What steps have been taken to ensure that all iron and steel plants which fall within the definition of the source category given above are included? Are gases from basic oxygen steel furnaces recovered and included with blast furnace gas? If not, how are the emissions from this source reported? Has a carbon balance check on blast furnaces been attempted? If not, what are the impediments to such a check?	For some smaller plants which fall within the definition, it may be difficult to obtain adequate data. In some plants there is a gas recovery system which transports, cleans and upgrades gases from various sources, including coke ovens. Where emissions are based on reported production and consumption of gases, care must be taken to avoid double counting of fuel combustion emissions in other sectors.
Recalculations/ Consistent time series	All gases	What changes have been made to the methodology since 1990, and how have they been incorporated into the series to maintain consistency?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.2.b, c, d, e and f: Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food, Beverages and Tobacco; Other Industry

Source Category	1.A.2.b, c, d, e and f Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food, Beverages and Tobacco; Other Industry - Overview
Definition	Includes emissions from fuel combustion for the generation of electricity and heat by the enterprises within the source category. Emissions from road transport by the industry should be reported under source category 1.A.3. However, emissions from off-road and other on-site, mobile machinery should be included here.
Potential Key Issues:	The main energy-consuming industries are grouped together, as the processes that produce emissions in each are similar. Ensuring that reporting conforms to the definition is primarily a matter of ensuring that the correct enterprises within the industries have been included. This is a data collection issue that is discussed below. Difficulties with the proper identification of emissions from fuel carbon that is used for non-energy applications or that leads to emissions in other sectors may arise in the chemicals source category, 1.A.2.c. In principle, this source category should exclude emissions from the use of fuels in offices of companies in the energy, transport and manufacturing source categories. However, it may not always be possible to distinguish this consumption from other uses. Where information is available, the distinction should be made and the excluded emissions reported under source category 1.A.4.a.
General References	See IPCC good practice guidance 2.1 and 2.1.1.4 for checks on data and emission factors. See also the Integrated Pollution Prevention and Control Handbook: 'Draft Reference Document on Best Available Techniques in the Large Volume Organic Chemical Industry,' dated October 2001. Non-ferrous metals (ISIC 272 and 2732), Chemicals (ISIC 24), Pulp, Paper and Print (ISIC 21 and 22), Food, Beverages and Tobacco (ISIC 15 and 16)

Source Category		1.A.2.b, c, d, e and f Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food, Beverages and Tobacco; Other Industry - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	What methods have been used to estimate the emissions from the industries in these source categories? Where deliveries of fuels provide the activity data, how have the non-fuel combustion uses been identified? How have fuel combustion emissions from processing petrochemical feedstocks been estimated? What method has been used?	Estimating emissions from the simple combustion of fuels should not present significant difficulties. Complications may arise in cases where part of the fuel is not combusted, or when by-products of non-energy feedstocks serve as fuel.
	CH_4, N_2O	To what extent has it been possible to apply plant specific methods? If special studies have been conducted, are the results available for others to use?	A variety of plant types are covered by these source categories. In some cases (e.g., cement manufacturing), it may be possible to obtain detailed information on furnace types, conditions and fuels used. Generally, however, most fuel use will be for conventional heating, and emission factors available from boiler specifications can be used.

Emission Factor	All gases	How have emission factors for unconventional and waste fuels been obtained and verified? What steps have been taken to ensure that factors for incomplete oxidation are realistic? What steps have been taken to obtain emission factors for the non-CO_2 gases for specific, large combustion plants? If emissions from lubricants are attributed to this source category, how has the fraction of lubricants combusted been deduced?	The varied activities within this group of enterprises may encompass waste or special fuels in, for example, the cement or chemical industries. In addition, some plant types will be specific to the processes used, and will therefore require special consideration. In some industries that use solid fuels, the combustion technologies may lead to higher levels of incomplete oxidation.
Activity Data Stationary Combustion	All gases	If the data are obtained from plant reports or sample surveys: Have the data been checked for consistency or adjusted to correspond with the total fuel delivered to the industry? If they have been obtained from deliveries data: Are direct imports of fuels included in the consumption figures? Are emissions from biofuel uses identified and quantified? Are emissions from waste and unconventional fuels sometimes used by the chemical and cement industries included?	Fuel consumption in these industries may be obtained from plant reports (usually only for large combustion plants) or sample surveys, or inferred from deliveries of fuels.
Mobile sources	All gases	If the data are obtained from plant reports or sample surveys: How have emissions from on-site mobile sources been included?	
Non-energy use	All gases	If, in the industrial processes and/or solvents sectors of the inventory, there are separate estimates of process emissions from the uses of fuels for non-energy purposes, has double counting of fuel combustion emissions occurred? How have feedstock uses been identified? If there is steam cracking of petrochemical feedstock, what procedure has been employed to identify the quantities of by-products used as fuel?	If fuel combustion emissions from this source category are partly based on deliveries of fuels to enterprises that use a portion of them for non-energy purposes, double counting of emissions may occur.
Completeness	All gases except N_2O.	Have carbon emissions from these source categories been checked against total carbon delivered to the constituent enterprises? Where differences exist, can they be satisfactorily explained by emissions in other sectors or by stored carbon? If stored carbon is the explanation, what stored carbon factor do the differences imply?	

Recalculations/ Consistent time series	All gases	If methods or data have improved since 1990, how has consistency of the series been maintained?	Feedstock use of fuels is a significant portion of oil use, and is increasingly a focus of research to find ways to improve emission estimates.
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.3.a: Civil Aviation

Source Category	**1.A.3.a Civil Aviation - Overview**		
Definition	Includes emissions from domestic air transport, including take-offs and landings. Excludes emissions from international civil aviation, which should be reported under CRF Table 1.C, as well as fuel consumption at airports for ground transport, which should be reported in CRF Table 1.A (a) under source category 1.A.3.e, Other Transportation. Also excludes emissions from stationary combustion at airports (to be reported under the appropriate stationary combustion category). See GPG 2.5.1 for a more detailed explanation of the activities to be included in this source category.		
Potential Key Issues:	An accurate separation of international and domestic emissions as well as the exclusion of any emissions from military aviation is highly dependent upon the methodology used, which will in turn be determined by the data available. However, note that for countries with negligible domestic air transport, the estimation of emissions is greatly simplified. The definitions of international and domestic flights are given in GPG 2.5.1.3. It is important to check whether the definitions have been met. See below under Methodology. Note in particular that the national territory may include distant islands, which will increase significantly the emissions attributed to domestic flights.		
General References	IPCC good practice guidance (GPG) 2.5.1 and 2.5.1.3		
Source Category		**1.A.3.a Civil Aviation - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Have emissions from international and domestic flights of all types except military flights been separated according to the definitions in GPG? If not, what obstacles were encountered? Have flights to all parts of the national territory been classified as "domestic" according to the IPCC definition? What part have deliveries of aviation fuels played in the estimation methodology?	CO_2 emissions are estimated from the type and quantity of fuel combusted. However, the quantities of fuels attributable to international, domestic and military aviation separately are usually determined through aircraft movements. If data are available on aircraft movements, LTOs and types, a Tier 2 methodology can be employed. Civil aviation includes elements of non-commercial traffic which should also be included. See GPG 2.5.1

	CH_4, N_2O	How have emissions of these gases been estimated? If national models have been used, are they fully documented, and where is the documentation available?	Given the current limited knowledge of emission factors, more detailed methodologies will not significantly reduce the uncertainties associated with CH_4 and N_2O emission estimates. (See GPG 2.5.1.1). The reviewer should consider the appropriateness of the methodology employed against the aviation activity of the country. In countries that have national models, these models should be used if they are well-documented and peer reviewed.
Emission Factor	CO_2	What is the source of the carbon emission factors for aircraft fuels? How have these factors been checked?	In some countries, the specifications of aviation fuels have changed since 1990.
	CH_4, N_2O	What is the source of the emission factors for aircraft fuels? How have these factors been checked?	Emission factors depend on engine types and modes of flight. However, GPG suggests use of constant emission factors for all aircraft based on fuel consumption, as the differences for aircraft/engine type are not readily available.
Activity Data Stationary Combustion	All gases	Are emissions from stationary combustion at airports excluded? If so, in which source category have they been placed (category 1.A.4.a is appropriate)?	There may be some use of aviation fuels for engine and airframe testing. This should be reported in 1.A.2.f. If information is available in the NIR on the fuels used to derive the emission estimates, only aviation fuels should be included. The presence of other fuels may indicate that emissions from ground sources have been included.
Mobile sources	All gases	What are the sources of aircraft activity data and fuel deliveries? If airports can import aviation fuel directly, how are these imports carried into the fuel use figures? Are emissions from aircraft support vehicles excluded and reported under source category 1.A.3.e?	The UNFCCC Reporting Guidelines state that emissions from aircraft support vehicles be reported under source category 1.A.3.e.
Completeness	CO_2	What checks have been done to show that the carbon emissions correspond well with deliveries of aviation fuels?	If the models from which emissions estimates are derived are constrained by the fuel delivery data, such checks are unnecessary.
Recalculations/ Consistent time series	All gases	Have any important changes in methods or data quality occurred over the time span of the inventory? Have any recalculations been conducted?	It is good practice to recalculate historic emissions when methods or data are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.

Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.3.b: Road Transportation

Source Category	**1.A.3.b Road Transportation - Overview**		
Definition	Includes all combustion and evaporative emissions from fuel use in road vehicles, including the use of agricultural vehicles on the highway. Emissions from the combustion of lubricants in road vehicles should be included, but there is neither an explicit requirement nor a methodology for this in the GPG.		
Potential Key Issues:	Emissions from off-road use of vehicles should be excluded and reported in the source category in which the use occurs.		
General References	IPCC good practice guidance (GPG) 2.3. IPCC Guidelines Vol3, 1.5.3		
Source Category		**1.A.3.b Road Transportation - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Does the methodology used conform to GPG recommendations? Has the Tier 2 method (bottom up) been used for CO_2 as a check? (This is considered good practice.) If so, the reviewer should record the conclusions. If estimates have been made using activity data other than fuel deliveries, what checks have been made to ensure that carbon emissions are consistent with fuel delivered?	Emissions of CO_2 are calculated on the basis of the carbon content of the fuel and its consumption. This is the preferred method, except in countries where national delivery statistics are unreliable (for example, where fuel smuggling occurs).
	CH_4, N_2O	Which methods have been used for estimating these gases? If a national model has been used, where may the documentation be found? Does the selection of the method conform to the GPG decision tree? If not, what are the impediments?	Emissions of CH_4 and N_2O are estimated by more complicated models using vehicle activity, fuel type and control technologies. If there is a well-documented national method it should be used, and the reviewer should note references to the method. There are three Tiers of increasing complexity for CH_4 and N_2O emission estimates (See GPG 2.3.1.1). Tiers 2 and 3 draw on or estimate fuel use by control technology, then apply different emission factors. Use of either Tier is good practice.

Emission Factor	CO_2	Which road transport fuels are in use? If there are modified or unusual fuels, what are the sources of their emission factors? Have they been checked for accuracy?	The carbon content of road transport fuels are well known, so the uncertainty should be very small. In countries where the fuels are modified (oxygenates) or of low quality, it may be necessary to check which emission factors are used.
	CH_4, N_2O	What are the sources of the emission factors? Does the national model offer advances in methods or data of value to other countries? What levels of uncertainty have been attributed to the emission factors? What actions are planned for improving the emission factors?	The uncertainty surrounding CH_4 and N_2O emission factors is estimated to be on the order of ± 40-50%, and represents the major source of uncertainty in this category.
Activity Data Mobile sources	CO_2	Where fuel deliveries data have been used: Are all fuels included (including less common fuels such as LPG and CNG)? How have all fuelling methods been included? Are the data complete? Are all direct imports included? Are there unrecorded fuel quantities entering the country? What methods have been used to exclude off-road fuel use?	These questions assume that fuel delivery data provide the basis for estimation of emissions. If this is not the case, the reviewer should check that the carbon estimates are consistent with delivery data. Where fuels serve purposes other than transport, it is important to confirm that the quantities concerned have been excluded from this source category and included in the proper source category.
	CH_4, N_2O	What are the types of data required for the modeling of these emissions? What are the sources of the data? Are any biofuels included?	Typically, emissions of non-CO_2 gases require details on vehicle technology, vehicle fleet characteristics, and total milage by vehicle category.
Completeness	All gases	Does the highway mobile source category include all emissions?	Emissions from road vehicles should be attributed to the country where fuel is loaded into the vehicle. (GPG 2.3.1.4)
Recalculations/ Consistent time series	All gases	Have the model or data changed significantly? Has recalculation of past emission estimates been required?	Steady improvement to methods for estimation of non-CO_2 emissions will require recalculation of the time series.
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.3.c: Railways

Source Category	1.A.3.c Railways - Overview		
Definition	Includes emissions from freight and traffic routes.		
Potential Key Issues:	Failure to limit fuel consumption data and emission estimates to locomotive use only. Emissions from stationary combustion by railway companies and by railway power stations should be excluded, and reported in source category 1.A.4.a.		
General References	IPCC Guidelines Vol. 3, 1.5.3.4. There is no specific IPCC good practice guidance.		
Source Category		**1.A.3.c– Railways - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	There are no methodological issues.	Carbon emissions are estimated from fuel consumption and carbon content of fuels used.
	CH_4, N_2O	Does the methodology employed differ in any way from that used for emissions from heavy diesel engines? If so, in what respects does it differ?	Fuel consumption data are used with emission factors for heavy diesel engines similar to those for road use.
Emission Factor	CO_2	What emission factors are used?	There should be little difficulty in obtaining accurate emission factors for gas oils.
	CH_4, N_2O	What emission factors are used?	See comment under Methodology, above.
Activity Data Stationary Combustion	All gases	How have the quantities of fuels used been identified or estimated?	Any fuel use for stationary combustion should be reported under source category 1.A.4a.
Mobile sources			The basis of data for consumption will usually be delivery statistics, or (for smaller countries) direct reports from the railway company.
Completeness	All gases	No source identification issues.	As the activity is clear and distinct and under the control of specific companies, there is usually no problem of ensuring complete coverage.
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.3.d: Navigation

Source Category	1.A.3.d Navigation - Overview		
Definition	Includes emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils. Sub-divided into international marine bunkers and national navigation.		
Potential Key Issues:	The major difficulty is ensuring an accurate split between international, national and naval emissions. Emissions from international marine bunkers should be excluded from national emission totals and reported separately. Some countries may have difficulty identifying fuel use for fishing (coastal or deep-sea) and excluding it from this source category. Emissions from fishing should be reported under source category 1.A.4.c. IPCC good practice guidance (GPG) 2.4 also discusses the estimation of emissions from naval fuel use, as the methodology employed is similar to that in this section. However, the emissions from naval activity should be reported in source category 1.A.5.b.		
General References	GPG 2.4.1.3 and 2.4		
Source Category		**1.A.3.d Navigation - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	No particular methodological issues.	There are two methodological approaches; both apply emission factors to fuel consumption data. The simpler approach (Tier 1) is used for CO_2 emissions.
	CH_4, N_2O	Which method has been employed? If the country is heavily involved in marine transport and has not used the more detailed method, what is the explanation?	Tier 2 is used for non-CO_2 emissions, and exists at two levels. In its most detailed form, it requires vessel and engine type information to obtain the specific emission factors.
Emission Factor	All gases	Have specific factors been used for marine oils? If not, has confirmation that the marine oils are identical to those used inland been obtained?	Check emission factors for oils used on international voyages, as they may differ from the factors available for nominally similar oils used inland. Oxidation factors may differ as well. Historically, fuels used for marine travel have had high sulphur contents and correspondingly lower carbon contents.
Activity Data Mobile sources	CO_2	What are the ultimate sources of the data? How has the country differentiated between national, fishing, international and naval fuel deliveries? If the procedure is not in conformity with the definition, what steps could reasonably be taken to improve conformity?	In some countries, fuel delivery data cannot discriminate easily between national, military and international deliveries (as defined in GPG 2.4.1.3). It is also likely that deliveries for international use will include quantities for deep-sea fishing, which should go under source category 1.A.4.c. Consumption of gas oil may include some stationary and off-road consumption.
	CH_4, N_2O	See information for CO_2 (above).	If the most detailed methods are used, the reviewer should record how the data are obtained, as the methods may be of use to other countries.
Completeness		What checks have been made on the use of all	Since emissions are ultimately linked to national fuel deliveries, all sources should

		deliveries of marine fuels?	be covered. Some fuel deliveries may be used for stationary combustion, so there is a risk of overestimating the emissions. Problems may arise from the division of the total emissions into national, international and naval emissions.
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.3.e: Other Transportation

Source Category	1.A.3.e Other Transportation – Overview
Definition	Includes combustion emissions from all remaining transport activities, including off-highway mobile sources such as earthmoving and construction equipment , ground activities in airports and harbours, and off-road activities not reported under source category 1.A.4.c (Agriculture/Forestry/Fisheries) or source category 1.A.2.f (Manufacturing Industries and Construction - Other). Military transport emissions should be reported under source category 1.A.5.b.
Potential Key Issues:	There will be many varied activities in this source category. For fuels such as gas oil and LPG, in some cases only a rough separation of stationary and mobile combustion may be possible.
General References	There is no recommended methodology for the source category.

Source Category		1.A.3.e Other Transportation - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	All gases	What sources are included, and what methods have been used for them?	
Emission Factor	All gases	What, if any, difficulties have been encountered in obtaining emission factors for this source category?	Emission factors are likely to be those used for other transport source categories.
Activity Data Stationary Combustion	All gases	Has it been possible to separate stationary from mobile source consumption when collecting data? If not, how have estimates been made?	There is unlikely to be any separate data on the use of fuels for stationary combustion at these facilities. Any estimates of emissions from stationary combustion should be reported under source category 1.A.4.a.
Mobile sources	All gases	What are the activity data?	Usually some auxiliary measure of activity is used to separate out a portion of deliveries of gas oil or other common fuels for allocation to this source category.
Completeness	All gases	How has complete coverage of all sources been demonstrated?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series		Have any recent changes been made to the estimation methods? If so, how have the results been carried into the time series?	If emission estimates are obtained from a more general model of off-road transportation, changes of the model will require to recalculations.
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.4.a: Commercial and Institutional

Source Category	1.A.4.a Commercial and Institutional - Overview
Definition	Includes emissions from fuel combustion in commercial and institutional buildings.
Potential Key Issues:	Possibility of double counting emissions by reporting off-road use of transport fuels here and in source category 1.A.3. Fuels for railway power stations should be included here. In principle, this source category should also contain emissions from the consumption of fuels in the offices of companies in the energy, transport and manufacturing source categories, but it may not always be possible to distinguish this consumption from that used in the source category activity. Where information is available the distinction should be made.
General References	ISIC 4103, 42, 6, 719, 72 (Computer and related activities), 8, 91 (Activities of membership organizations n.e.c.) through 96 (Undifferentiated goods-producing activities of private households for own use).

Source Category		1.A.4.a Commercial and Institutional - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	What estimation methods have been used?	The simple combustion formula is applicable.
	CH_4, N_2O	Are data on types of combustion plant available? If not, how have the estimates been made?	Emissions are based on fuel consumed and type of combustion plant.
Emission Factor	CO_2	What is the origin of the emission factors for waste and any non-marketed fuels (e.g., unconventional biofuel)?	Check the origin of emission factors for waste combustion, and confirm that they relate to *fossil* carbon content only.
	CH_4, N_2O	See information for CO_2 (above).	Average emission factors will be employed, with plant-specific factors used only where plant type and fuel consumption are known.
Activity Data Stationary Combustion	CO_2	How have the data for consumption of non-marketed fuels been obtained? Has data confidentiality complicated the collection or use of the data?	Fuel combustion data will be varied, and will cover both conventional and waste (hospital and municipal) fuels used for energy production.
	CH_4, N_2O	See information for CO_2 (above).	Disaggregation of fuel consumption by plant type will be difficult, and is likely to exist only for large plants.
Mobile sources	All gases	What methods have been employed to ensure that off-road emissions have been included?	
Completeness	All gases	What checks have been applied to ensure that all sources have been included (emissions from autogeneration and off-road sources in particular)?	Source category should include electricity generation within non-manufacturing enterprises, airports, public establishments, sewage works and railway companies. The size of autogeneration (on-site) plants may mean that information on their emission characteristics are known and data are available. The danger of excluding these sources arises only when the sources might be considered to belong to another source category (for example, transport or public electricity generation).
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national

		QA/QC prodedures were implemented?	circumstances.

Table 1.A.4.b: Residential

Source Category	**1.A.4.b Residential – Overview**		
Definition	Emissions from fuel combustion by households.		
Potential Key Issues:			
General References	IPCC Guidelines Vol. 3, 1.5.1 and 1.5.2. No specific IPCC good practice guidance for households source category.		
Source Category		**1.A.4.b Residential - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Which methods have been used? What factors for incomplete oxidation have been employed for this source category?	Estimation method is usually the direct application of carbon content to fuel consumption, but reliable data for stockable fuels is hard to obtain.
	CH_4, N_2O	See information for CO_2 (above).	In addition to the points above, adequate estimation requires data on numbers and types of combustion appliances and mobile equipment. Most estimation will probably proceed from consumption figures and the application of an average emissions factor. Note that inclusion of CH_4 and N_2O emissions due to biomass consumption may also be required, as it can be significant in less industrialised countries.
Emission Factor	CH_4, N_2O	How have emission factors been obtained, and what checks have been made to ensure that they are representative of household use?	The characteristics of solid fuels and biofuels in particular are variable. The conditions of their combustion are also less well controlled than for large installations.
Activity Data Stationary Combustion	CO_2	What checks have been made on consumption figures using household surveys (where they exist)? Is any account taken of unrecorded use of natural gas due to theft or metering practices?	CO_2 emissions will be based on fuel deliveries and estimates of consumption.
	CH_4, N_2O	How have the appliance numbers been estimated? If biomass fuel is important, how have the data been obtained and verified?	Non-CO_2 emissions will require data on numbers and types of plant by fuel type.
	CH_4, N_2O	How have non-CO_2 emissions been estimated for this category?	Non-CO_2 emissions will require data on numbers and types of equipment by fuel type.
Completeness		What information is available on the extent to which data on fuel use in places of commerce (i.e. shops and small offices) and households has been intermingled?	This is a major statistical problem in developing countries.

Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.4.c: Agriculture, Forestry and Fishing

Source Category	**1.A.4.c Agriculture, Forestry and Fishing - Overview**		
Definition	Includes emissions from fuel combustion in these three areas, including coastal and deep-sea fishing. Other activities included are traction vehicles, pumping fuel use, grain drying and horticultural greenhouses. Emissions from agricultural vehicles used on highways should be excluded.		
Potential Key Issues:	Reviewer should confirm that national fishing is included here and not in Navigation.		
General References	No specific guidance in the IPCC Guidelines or IPCC good practice guidance. ISIC 5 (Fishing, aquaculture and service activities incidental to fishing), 1302.		
Source Category		**1.A.4.c Agriculture, Forestry and Fishing - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	All gases	What estimation methods have been employed? How have the mobile source estimates been derived?	This source category contains a mix of off-road mobile plants and stationary sources, so estimation will draw upon the methods employed in other source categories.
Emission Factor	CH_4, N_2O	What are the sources of emission factors for this source category? If biofuels are used, what factors are applied, and what is their origin?	Any research conducted to improve the emission factors should be noted.
Activity Data Stationary Combustion	All gases	How have data for biofuels been obtained?	CO_2 emissions can use statistics of fuel consumption as a basis of estimation.
	CH_4, N_2O	Have estimates of consumption for each plant type been used, or have only average factors been applied to total consumption figures?	Requires quantities of fuel used by each fixed plant type. If unavailable, average factors will have to be applied to fuel consumption in the source category.
	CO_2	How have data for mobile sources been estimated?	Data relating to deep-sea fishing may be difficult to obtain. See source category 1.A.3.d, above.
	CH_4, N_2O		Estimates will depend on stocks of off-road equipment and its fuel types
Completeness	All gases	What checks are applied to confirm inclusion of all sources?	Check to ensure that no double counting occurs between this category and category 1.A.3.e (Other Transportation).

Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.5.a: Other (Stationary)

Source Category	**1.A.5.a Other (Stationary) - Overview**		
Definition	Includes all remaining emissions from non-specified fuel combustion, including emissions from military fuel use.		
Potential Key Issues:	Completeness: due to the miscellaneous nature of the source category, it is difficult to ensure that all combustion emissions that have not been included in any other category have been included here.		
General References	No specific guidance in IPCC Guidelines or IPCC good practice guidance.		
Source Category		**1.A.5.a Other (Stationary) - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	All gases	State what is included in the source category and what methods have been used.	The 'miscellaneous' character of the source category will limit methods to simple estimates, as detailed information will not typically be available.
Emission Factor	All gases	What is the source of the emission factors? If there are any used which have not been employed elsewhere, how have they been checked?	Transparency requires documentation for key assumptions and methods.
Activity Data Stationary Combustion	All gases	If there is confidential data, to what extent has the estimate been limited by it?	The quality of estimates depends largely on the availability of data for uses in this source category. The military use data may be considered confidential, and in this case estimation of consumption will be required.
	CH_4, N_2O	How have the relevant activity data been obtained?	Requires quantities of fuel used by each fixed plant type. If unavailable, average factors should applied to fuel consumption in the source category.
Completeness	All gases	What checks have been applied to ensure that all sources are included?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these	It is good practice to report on the sources of uncertainties in national inventories.

		uncertainties quantified?	
Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A.5.b: Other (Mobile)

Source Category	**1.A.5.b Other (Mobile) - Overview**		
Definition	All remaining emissions from non-specified fuel combustion. Includes emissions from military fuel use, as well as vehicles and other machinery, marine craft and aviation.		
Potential Key Issues:	Primarily military activity which may show exceptional levels in years where the national forces are brought into action.		
General References	IPCC good practice guidance (GPG) 2.4.1.3 and 2.5.1.3.		
Source Category		**1.A.5.b Other (Mobile) - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	All gases	What sources have been included in the source category, and what methods have been used?	There are few issues that are different from those under civil aviation and navigation. Some aircraft and vessels may have different engine types or systems which need to be taken into consideration. Main problem is data availability (see below).
Emission Factor	All gases	What is the source of the emission factors for unusual sources?	Military marine navigation may include unique operations, situations, and equipment without a civilian analogue. In countries with significant naval forces emission factors for these sources should be discussed with military experts.
Activity Data Mobile Sources	All gases	If there is confidential data, to what extent has the estimate been limited by it? How has stationary been separated from mobile consumption for fuels that can be used for both?	It is difficult to identify and quantify consumption for military purposes, as many countries consider the data to be sensitive. Also, where gas oil may be used for stationary and mobile sources, an accurate separation of the quantities for each is unlikely without access to detailed records maintained by the military.
Completeness	All gases	What checks have been applied to ensure that all sources are included? Do military mobile source emissions distinguish between domestic and international transport?	It is good practice to apply the rules defining civilian national and international operations in navigation to military operations where they are comparable. If data on the fuel split are unavailable, all fuels used for military activities should be treated as domestic (GPG 2.4.1.3).
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All gases	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.

Reporting and documentation	All gases	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	All gases	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 1.A(c) - Comparison of CO2 Emissions from Fuel Combustion

Source Category	1.A(c) Comparison of CO_2 Emissions from Fuel Combustion	
Definition	The UNFCCC reporting guidelines (in accordance with the IPCC Guidelines) require that Parties compare CO_2 emissions estimated using the sectoral approach and the reference approach. Such comparison may assist in verifying the sectoral estimates.	
Potential Key Issues:	Discrepancies between the Reference and Sectoral Approach	
General References	IPCC good practice guidance, Chapter 2.1.1 IPCC Guidelines – Reference Manual (Volume 3, Chapter 1.4.1, pages 1.88 to 1.33)	
Detailed Review Element	**Questions**	**Elaboration/Clarification**
Methodology	Are there discrepancies between the two approaches?	Comparison of AD using the reference approach with AD using the sectoral approach should be considered as a tool in assessing inventories, and the results should not in themselves be considered as indicating an inventory problem. The ERT should always consider the Party's explanation for any discrepancies between the two approaches and consider whether the emission factors (EFs) and AD used by the Party in the sectoral and reference approaches are appropriate. In considering differences between a Party's estimates using the sectoral approach and those obtained using the reference approach, ERTs should consider whether such differences can be adequately explained by differences in the level of aggregation of AD and other input parameters. ERTs should consider, to the extent possible, the Party's particular procedures for the collection of energy statistics, as well as any specific characteristics of its energy statistics. ERTs should also consider whether the same fuels are included in the estimation of the reference approach as in the sectoral approach (for instance, feedstocks are often excluded from the reference approach). In cases where procedures for the collection of energy statistics are well established and the differences between the reference and sectoral approaches can be adequately explained by characteristics of the Party's national energy statistics, any difference between the reference and the sectoral approaches need not be considered further.

Fugitive Emissions From The Energy Sector (Section 1.B)

Introduction

11. Fugitive emissions in the energy sector comprise all GHG emissions from associated non-combustion sources and venting and flaring activities. The category is divided into three main subcategories: solid fuels (primarily coal); oil and natural gas systems; and other. The first two subcategories cover the exploration, production, gathering, processing or refining, transmission, transport, storage and distribution of fossil fuels. The last subcategory, although not specifically addressed in the IPCC Guidelines, is provided in the UNFCCC CRF to capture fugitive GHG emissions associated with other types of energy production (e.g., from geothermal power production). For solid fuels, venting and disposal of coal-bed methane is the primary source of fugitive GHG emissions. Most of these emissions occur at the mine, with some residual emissions occurring from post-mining handling/processing activities.

12. Oil and gas systems are potentially very complex and usually much more diverse than implied by the UNFCCC CRF. Specific fugitive emission rates may vary greatly according to the type of oil or gas being produced, processed or handled (e.g., conventional crude oil, heavy oil, crude bitumen, dry gas, sour gas, associated gas), the stage of the system, the type and age of facility, operating, maintenance and design practices as well as local regulatory requirements and enforcement. Two major issues concerning the reported fugitive emissions from oil and gas systems are: (1) the generally poor quality and completeness of available venting and flaring data, (2) the fact much of the infrastructure contributing to equipment leaks is at minor facilities for which statistics are either unavailable or incomplete (e.g., well-site facilities and field facilities).

13. Estimates of venting and flaring emissions are often suspect, because they are usually only rough estimates and are often incomplete. Local reporting requirements may not necessarily require tracking of all vented and flared volumes. For example, while some North American provinces and states require companies to report casing gas venting at heavy oil wells, others do not. Normally there is no metering on vent or flare systems, especially on emergency-relief and blowdown systems. Even in advanced countries with highly regulated oil and gas industries, it is not uncommon for many operating facilities to incorrectly report zero vented and flared volumes. In many cases, the reported volume is a balancing term calculated to reconcile production accounting reports, and may therefore contain significant uncertainties due both to metering errors and to the fact that substantial venting and flaring may occur upstream of any metering. This latter point is of particular concern in countries where the industry is effectively monopolized by a single national petroleum company, since in such cases there is often metering at the final sales points only.

14. An additional concern is that in cases where vented and flared statistics are provided, they are usually reported as a combined value rather than as separate vented and flared fractions. The actual split has a significant impact on the total CO_2-equivalent emissions from these activities, since unburned methane has a global warming potential 21 times higher than CO_2, which is a product of methane combustion.

15. The primary types of fugitive emission sources at oil and gas facilities are fugitive equipment leaks, process venting and flaring, evaporation losses (i.e. from product storage and handling, particularly where flashing losses occur), and accidental releases or equipment failures. The latter may include well blowouts, pipeline breaks, tanker accidents, tank explosions, gas migration to the surface around the outside of wells, surface casing vent blows, and leakage from abandoned wells. Gas migration to the surface may be caused by a leak in the production string at some point below the surface casing, or by the migration of material from one or more of the hydrocarbon-bearing zones which were penetrated (e.g., a

coal seam). A surface-casing vent blow may be caused by a leak from the production casing into the surface casing, or by fluid migration up into the surface casing from below. Emissions from abandoned wells result from unsuccessful abandonment procedures.

16. Regulations, economic incentives to reduce product loss, on-site utilization opportunities and cost-effective emission reductions are usually the most significant factors affecting the amount of venting and flaring at oil and gas facilities.

17. Production statistics for coal, oil and gas are available for most countries from the International Energy Agency (IEA), the United Nations Statistics Department (UNSD), and the U.S. Energy Information Administration (EIA), as well as from the respective national agencies. Additional oil and gas data are available from international surveys conducted by Oil and Gas Journal.

18. This document comprises a main section and three addenda: a series of summary tables to guide the reviewer through the technical review of each major source category; a series of flow diagrams to help delineate the different parts of the oil and gas industry to be reviewed; and a glossary of key industry-specific terms and facility definitions to be considered.

Table 1.B.1: Solid Fuels (Section 1.B.1, including 1.B.1.a Coal Mining and Handling, 1.B.1.b Solid Fuel Transformation, and 1.B.1.c Other)

Source Category	1.B.1 Solid Fuels - Overview		
Definition	This category is subdivided into fugitive methane emissions from coal mining and post-mining handling activities such as transportation and processing (e.g., breaking, crushing and thermal drying), solid fuel transformation (such as metallurgical coke production), and other sources (e.g., from abandoned mines and waste piles). Venting and disposal of coal-bed methane is the primary source of fugitive GHG emissions. Most of these emissions occur at the mine, with some residual emissions occurring from post-mining activities. Where coal-bed methane is produced on its own merits and there are no plans to exploit the coal reserve, fugitive emissions from the gas development should be classified under oil and gas systems (source category 1.B.2), and not under solid fuels. If the mine gas is recovered and used as fuel, the resulting combustion emissions should not be classified as fugitive emissions.		
Potential Key Issues:	Evaluating the basis for the assumptions and approximations made. Determining the degree to which a Party's methodology and QA/QC protocols are actually implemented. Accounting for the significant natural variability of underground mines. See IPCC good practice guidance (GPG), page 2.75). No IPCC methodology exists for solid fuel transformation.		
General References	UNFCCC Common Reporting Format (Table 1.B.1, page 36 of FCCC/SBSTA/2004/8) IPCC Guidelines – Workbook (Modules 1.6, pages 1.27 to 1.30 and 1.71) IPCC Guidelines – Reference Manual (Chapters 1.8, pages 1.114 to 1.134) GPG (Chapters 2.6, pages 2.70 to 2.78)		
Source Category		**1.B.1 Solid Fuels - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4 and CO_2	Check whether the same method has been used for all individual sources.	It may be that different tiers are used for different mines to suit the available activity and monitoring data.
		Check that the stated method has in fact been applied.	For example, extrapolation of Tier 3 estimates for a few mines is effectively the same as applying a Tier 2 approach.
Emission Factors	CH_4 and CO_2	Check that the selected emission factors are within the range of values provided in the IPCC Guidelines, or that departures from this are adequately justified. Also, confirm that the emission factors are expressed using the same units of measure and reference conditions as the activity data, or that appropriate conversion factors have been applied.	For coal mining and handling, the implied emission factors should generally be compared to the corresponding Tier 1 values presented in the IPCC Guidelines. Where the implied emission factors are significantly less than the IPCC values, this may be due to emission control measures applied by the Party (e.g., mine degasification and vent gas treatment or recovery). Significant differences may also occur due to national differences in the gas content of different coal deposits and the extent of degasification.
		Check that good practice has been used in	Refer to Section 2.6.1.2 (pages 2.74 to 2.75) of the GPG. The quality and

		selecting the emission factors.	applicability of the factors are important considerations.
Activity Data	CH_4 and CO_2	Compare the reported activity data against corresponding values published international agencies.	Unless otherwise noted, coal statistics usually include both primary (including hard coal and lignite) and derived fuels (including patent fuel, coke oven coke, gas coke, brown coal/peat briquettes (BKB), coke oven gas and blast furnace gas). Peat is also included in this category. The statistics typically summarize total coal consumption, production, reserves, trade, and average heat content. Breakdowns are also given by type of coal produced (i.e., anthracite, bituminous or lignite). At the international level the published statistics do not provide information regarding the method of mining (i.e., surface/strip or underground) or depth of mines although these data are usually collected and sometimes available on special request. In the absence of any information on the type of mining, a conservative first approximation is to assume that all lignite coal is surface mined and all bituminous and anthracite coal is produced from underground mines. This will tend to overstate emissions since substantial amounts of bituminous coal and lesser amounts of anthracite coal are produced from surface mining operations. Worldwide, it is reported that some 60 percent of all coal production is from surface mining.
		Check that good practice has been followed for collection of the activity data.	Refer to Section 2.6.1.3 (page 2.75) of the GPG.
Completeness	CH_4 and CO_2	Check that all applicable subcategories and sub-sources have been fully addressed. If not, evaluate whether the omitted subcategories and sub-sources are likely to be key sources on the basis of the reviewer's judgment.	Refer to Section 2.6.1.4 (page 2.76) of the GPG. There should be estimates for underground mining, surface mining and post-mining handling activities.
		Check that emissions of all applicable gases are fully accounted for, and that any omissions or simplifications are reasonable on the basis of the reviewer's	CH_4 is the principal GHG emitted due to coal mining and handling activities. The emitted gas may also contain some naturally occurring CO_2; the relative amount may vary greatly between coal seams, and may be significant in some cases. If

		judgment.	degasification wells with waste gas flaring are employed or the ventilation systems for underground mines are equipped with vent-gas controls (e.g., catalytic oxidizers), greater amounts of CO_2 and some N_2O will be emitted. The CRF currently does not allow for reporting of N_2O as a fugitive emission from solid fuels.
Recalculations/Consistent Time Series	CH_4 and CO_2	Check that good practice has been used to maintain consistent time series.	Refer to Section 2.6.1.5 (page 2.76) and Section 7.3 (pages 7.13 to 7.21) of the GPG.
Uncertainty	CH_4 and CO_2	Check that the Party has estimated the uncertainty in its reported emissions, and that the selected method is consistent with good practice.	The Party should be evaluating the uncertainty in their emission estimates. The values should be based on a 95-percent confidence interval. Refer to Sections 2.6.1.6 (pages 2.76 to 2.77) and Section 6 (pages 6.1 to 6.34) of the GPG.
Reporting and Documentation	CH_4 and CO_2	Check that the Party has used good practice in reporting and documenting its emissions inventory.	Refer to Section 2.6.2 (page 2.77) of the GPG.
QA/QC	CH_4 and CO_2	Check that good practice has been used to help ensure completeness and to avoid any double counting or omission of data.	Refer to Section 2.6.3 (page 2.78) and Section 8 (pages 8.1 to 8.17) of the GPG.

Table 1.B.2.a: Oil Systems

Source Category	1.B.2.a Oil Systems - Overview
Definition	This category accounts for all direct GHG emissions, except those from fuel combustion, which may be attributed to oil exploration, production, transportation, refining, storage and final distribution activities. Storage losses at production facilities, fugitive equipment leaks at sites with extensive natural gas fuel systems and accidental releases and equipment failures will be the primary sources of emissions. Emissions from venting and flaring should be broken out and reported under source category 1.B.2.c.
Potential Key Issues:	Evaluating the Party's assessment of the completeness and reliability of its reported source counts. Avoiding confusion due to potential differences in terminology, design and operating practices, and the reporting basis of activity data between Parties. Distinguishing between missed or underestimated emissions and the impact of control measures implemented by the Party. Identifying classification of emissions (e.g., reporting fugitive emissions from oil transport under oil production). Apportioning between oil related emissions and gas related emissions in the upstream oil and gas industry can be difficult, resulting in inconsistent categorization of emissions across the category. Evaluating the basis for the assumptions and approximations made. Determining the degree to which a Party's methodology and QA/QC protocols are actually implemented. This may best be evaluated through in-country reviews.
General References	UNFCCC Common Reporting Format (Table 1.B.2, page 37 of FCCC/SBSTA/2004/8)

	IPCC Guidelines – Workbook (Module 1.5 – pages 1.24 to 1.26 and 1.70) IPCC Guidelines – Reference Manual (Volume 3, Chapter 1.7, pages 1.99 to 1.113) IPCC good practice guidance (GPG) (Chapter 2.7, pages 2.79 to 2.93)		
Source Category		**1.B.2.a Oil Systems - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4 and CO_2	Check that the stated method has in fact been applied.	The NIR should either describe the method(s) used or provide an appropriate reference for the method(s) (e.g., IPCC Tier 1, Tier 2, Tier 3, country-specific method, CORINAIR, etc.). In most cases, it is likely that a combination of approaches has been used to assess fugitive emissions from the different stages of each system. The applicable IPCC methodology decision trees for assessing fugitive emissions are presented in Figures 2.13 and 2.14 in the GPG. Key categories should be evaluated using a Tier-3 method. The elements of a Tier-3 method are not well defined for oil systems. It is generally a rigorous bottom-up assessment approach, involving the development of detailed source counts coupled with the use of emission factors, production statistics and possibly some source modeling and measurement data. If the emissions reported for a source or sub-source have been determined based on a roll-up of inventories from individual companies, all companies should have utilized a common methodology. If they have not, the differences between them and their corresponding impacts should be documented.
Emission Factors	CH_4 and CO_2	Check that good practice has been used in selecting the emission factors.	Refer to Section 2.7.1.2 (pages 2.84 to 2.87) of the GPG. The quality and applicability of the factors are important considerations.
		Check that the selected emission factors are within the range of values provided in the IPCC Guidelines, or that departures from this are adequately justified. Also, confirm that the emission factors either are expressed using the same units of measure and reference conditions as the activity data, or that appropriate conversion factors have been applied.	The potential range in Tier-1 CH_4 emission factors is given in Tables 1-57 and 1-58 of the IPCC Guidelines. Some fugitive CO_2 emissions may occur due to the presence of naturally occurring CO_2 in natural gas losses at oil facilities.
Activity Data	CH_4 and CO_2	Check that appropriate activity data are being applied	The required activity data depends on the part of the system being considered and the emission assessment method used as summarized in Table 2.17 of the GPG

			(page 2.89). The only infrastructure data potentially required for application of IPCC Tier-1 approaches are well counts and the lengths of pipeline systems. Facility information is currently only required for IPCC Tier-3 methods. It is important to identify the measures undertaken to ensure completeness and accuracy of the compiled information, and to evaluate the validity of any assumptions made (e.g., extrapolations, interpolations, constancy, etc.),
		Compare the reported activity data against corresponding values published against international agencies. Are there any significant discrepancies, and can they be explained?	Refer to the glossary of key oil and gas related terminology following this section.
		Check that good practice has been followed for collection of the activity data.	Refer to Section 2.7.1.3 (page 2.88 to 2.90) of the GPG.
		Check the assumptions used to develop source populations and bridge gaps in activity data. What measures have been taken to ensure completeness and to avoid any double counting or omission of data?	Infrastructure data are more difficult to obtain than production statistics, and the use of consistent terminology and clear and accurate definitions is critical in developing proper equipment counts. Information concerning the numbers and types of major facilities, the types of processes used at these facilities, the numbers and types of active wells, the numbers of wells drilled, and the lengths of pipeline are typically available only from national agencies, if at all. Information on minor facilities (e.g., wellhead equipment, pigging stations, field gates, and pump stations) usually is not available, even from the oil companies themselves.
Completeness	CH_4 and CO_2	Check that all applicable subcategories and sub-sources have been fully addressed. If not, evaluate whether the omitted subcategories and sub-sources are likely to be key sources on the basis of the reviewer's judgment.	Refer to Section 2.7.1.4 (pages 2.90 to 2.91) of the GPG. The different subcategories that may apply are summarized in Table 2.15 of the GPG (page 2.83).
		Check that emissions of all applicable gases are fully accounted for, and that any omissions or simplifications are reasonable on the basis of the reviewer's judgment.	CH_4 should be the dominant GHG emitted. A small amount of naturally occurring CO_2 will be associated with all natural gas losses. The amount of CO_2 depends on the reservoir and sometimes on the type of production techniques employed, but generally increases with the depth of the

			reservoir.
Recalculations/Consistent Time Series	CH_4 and CO_2	Check that good practice has been used to maintain consistent time series.	Refer to Section 2.7.1.5 (page 2.91) and Section 7.3 (pages 7.13 to 7.21) of the GPG.
Uncertainty	CH_4 and CO_2	Check that the Party has estimated the uncertainty in its reported emissions, and that the selected method is consistent with good practice.	Each Party should be providing a quantitative estimate of the uncertainty in their reported emissions. The values should be based on a 95 percent confidence interval. Refer to Section 2.7.1.6 (pages 2.91 to 2.92) and Section 6 (pages 6.1 to 6.34) of the GPG.
Reporting and Documentation	CH_4 and CO_2	Check that the Party has used good practice in reporting and documenting its emissions inventory.	Refer to Section 2.7.2 (pages 2.92 to 2.93) of the GPG
QA/QC	CH_4 and CO_2	Check that good practice has been used to help ensure completeness and to avoid any double counting or omission of data.	Refer to Section 2.7.3 (page 2.93) and Section 8 (pages 8.1 to 8.17) of the GPG. Problems are likely to arise due to the lack of clearly documented definitions of key activity parameters, the need to make assumptions to bridge certain data gaps, and a lack of information on field facilities (e.g., compressor stations on gathering systems, field dehydrators, wellsite facilities, etc.) in the upstream oil and gas industry.

Table 1.B.2.b: Gas Systems

Source Category	1.B.2.b Gas Systems - Overview
Definition	This category accounts for all direct GHG emissions, except those from fuel combustion, which may be attributed to gas exploration, production, processing, transmissions and final distribution activities. The primary emission sources include fugitive equipment leaks, storage losses, and accidental releases and equipment failures. Emissions from venting and flaring should be broken out and reported under source category 1.B.2.c.
Potential Key Issues:	Evaluating the Party's assessment of the completeness and reliability of its reported source counts. Avoiding confusion due to potential differences in terminology, design and operating practices and the reporting basis of activity data between Parties. Distinguishing between missed or underestimated emissions, and the impact of control measures implemented by the Party. Identifying incorrect classification of emissions based on the available high-level reporting information for the Party. Apportioning between oil related emissions and gas related emissions in the upstream oil and gas industry can be difficult, resulting in inconsistent categorization of emissions across the category. Evaluating the basis for the assumptions and approximations made. Determining the degree to which a Party's methodology and QA/QC protocols are actually implemented. This may best be evaluated through in-country reviews.
General References	UNFCCC Common Reporting Format (Table 1.B.2, page 37 of FCCC/SBSTA/2004/8) IPCC Guidelines – Workbook (Module 1.5 – pages 1.24 to 1.26 and 1.70) IPCC Guidelines – Reference Manual (Volume 3, Chapter 1.7, pages 1.99 to 1.113) IPCC good practice guidance (GPG) (Chapter 2.7, pages 2.79 to 2.93)

Source Category		1.B.2.b Gas Systems - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4 and CO_2	What IPCC methodology tier or other method has been applied, and is it consistent with good practice? Check that the stated method has in fact been applied. What measures have been taken to ensure complete coverage of the industry, and to avoid double counting or omission of data?	The applicable methodology decision trees for assessing fugitive emissions are presented in Figure 2.12 of the GPG. In general, emissions should be evaluated using the best information available. Where sources are key sources to the Party's national GHG emissions, a Tier-3 method should be applied. For gas systems a Tier-3 method is a rigorous bottom-up assessment approach, involving the development of detailed source counts coupled with the use of emission factors, production statistics and possibly some source modeling and measurement data. In most cases, it is likely that a combination of approaches have been used to assess fugitive emissions from the different stages of each system. If the emissions reported for a source or sub-source have been determined based on a roll-up of inventories from individual companies, all companies should have utilized a common methodology. If they have not, the differences between them and their corresponding impacts should be documented.
Emission Factor	CH_4 and CO_2	Check that good practice has been used in selecting the emission factors.	Refer to Section 2.7.1.2 (pages 2.84 to 2.87) of the GPG.
		Check that the selected emission factors are within the range of values provided in the IPCC Guidelines, or that departures from this are adequately justified. Also, confirm that the emission factors either are expressed using the same units of measure and reference conditions as the activity data, or that appropriate conversion factors have been applied.	The potential range in Tier-1 CH_4 emission factors is given in Tables 1-57 and 1-58 of the IPCC Guidelines. Similar factors showing the potential range in natural gas losses for different parts of the gas system are given in GPG Table 2.18 of the GPG. Fugitive CO_2 emissions may occur due to the presence of some naturally occurring CO_2 in raw natural gas.
Activity Data	CH_4 and CO_2	Check that appropriate activity data are being applied.	The required activity data depends on the part of the system being considered and the emission assessment method used, as summarized in Table 2.17 of the GPG (page 2.89). The only infrastructure data potentially required for application of IPCC Tier-1 approaches are well counts and the lengths of pipeline systems. Facility information is

Source Category		1.B.2.b Gas Systems - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
			currently only required for IPCC Tier-3 methods.
		Compare the reported activity data against corresponding values published against international agencies.	Refer to the glossary of key oil and gas related terminology following this section. Note that gas production data reported by international sources are expressed on a net basis (i.e. after shrinkage, losses, and re-injected, vented and flared volumes). When data are expressed on an energy basis, UNDS and IEA apply the net calorific values, while EIA uses the gross calorific value (the convention varies between national reporting agencies). Natural gas includes gas originating from gas wells, conserved gas produced in association with crude oil, and methane recovered from coalmines (colliery gas).
		Check that good practice has been followed for collection of the activity data.	Refer to Section 2.7.1.3 (page 2.88 to 2.90) of the GPG.
		Check the assumptions used to develop source populations and bridge gaps in activity data. What measures have been taken to ensure completeness and to avoid any double counting or omission of data?	It is important to identify the measures undertaken to ensure completeness and accuracy of the compiled information, and to evaluate the validity of any assumptions (e.g., extrapolations, interpolations, constancy, significance, etc.) used to bridge data gaps. Most of the target emissions will tend to come from the many smaller facilities rather than the few larger ones, yet reliable information on the smaller facilities is difficult to obtain, and when available is usually incomplete. In Canada, where the population is widely dispersed over a large geographic area, there is 7.0 m of distribution main per capita for provinces in which gas service is provided. The average for the entire United States is 5.6 m per capita. These values would be expected to provide an upper limit on the length of distribution main per capita. Convenient checks for other source estimates are not as readily available.
Completeness	CH_4 and CO_2	Check that all applicable subcategories and sub-sources have been fully addressed. If not, evaluate whether the omitted subcategories and sub-sources are likely to be key sources on the basis of the reviewer's judgment.	Refer to Section 2.7.1.4 (pages 2.90 to 2.91) of the GPG. The different subcategories that may apply are summarized in Table 2.15 of the GPG (page 2.83).
		Check that emissions of all	CH_4 should be the dominant GHG emitted.

Source Category		1.B.2.b Gas Systems - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
		applicable gases are fully accounted for, and that any omissions or simplifications are reasonable on the basis of the reviewer's judgment.	A small amount of naturally occurring CO_2 will be associated with all natural gas losses. The amount of CO_2 in raw natural gas depends on the reservoir and sometimes on the type of production techniques employed, but generally increases with the depth of the reservoir.
Recalculations/Consistent Time Series	CH_4 and CO_2	Check that good practice has been used to maintain consistent time series.	Refer to Section 2.7.1.5 (page 2.91) and Section 7.3 (pages 7.13 to 7.21) of the GPG.
Uncertainty	CH_4 and CO_2	Check that the Party has estimated the uncertainty in its reported emissions, and that the selected method is consistent with good practice.	The Party should be evaluating the uncertainty in their emission estimates. The values should be based on a 95 percent confidence interval. Refer to Section 2.7.1.6 (pages 2.91 to 2.92) and Section 6 (pages 6.1 to 6.34) of the GPG.
Reporting and Documentation	CH_4 and CO_2	Check that the Party has used good practice in reporting and documenting its emissions inventory.	Refer to Section 2.7.2 (pages 2.92 to 2.93) of the GPG.
QA/QC	CH_4 and CO_2	Check that good practice has been used to help ensure completeness and to avoid any double counting or omission of data.	Refer to Section 2.7.3 (page 2.93) and Section 8 (pages 8.1 to 8.17) of the GPG. Problems are likely to arise due to the lack of clearly documented definitions of key activity parameters, the need to make assumptions to bridge certain data gaps, and a lack of information on field facilities (e.g., compressor stations on gathering systems, field dehydrators, wellsite facilities, etc.) in the upstream oil and gas industry.

Table 1.B.2.c: Venting and Flaring

Source Category	1.B.2.c Venting and Flaring - Overview
Definition	This category accounts for all direct GHG emissions from venting and flaring activities that may be attributed to oil and gas exploration, production, processing/refining, transmissions and final distribution activities. Venting and flaring is potentially a major source of GHG emissions from the oil and gas industry. Neither the IPCC Guidelines nor the IPCC good practice guidance (GPG) provides a clear definition of venting emissions. Venting emissions should comprise all intentional and emergency discharges of natural gas to the atmosphere. These releases may occur on either a continuous or intermittent basis, and may comprise the following: Use of natural gas as the supply medium for gas operated devices (e.g., chemical injection pumps, starter motors on compressor engines and instrument control loops), Pressure relief and disposal of off-specification product during process upsets, Purging and blowdown events related to maintenance and tie-in activities, Disposal of off-gas streams from gas treatment units (e.g., still-column off-gas from glycol dehydrators, emulsion treater overheads and stabilizer

	overheads), Separator off-gas disposal at oil facilities where there is no gas conservation or re-injection, Gas releases from pigging and well-testing activities, Disposal of casing-head gas, Solution gas emissions from storage tanks, and Biogenic gas formation and evaporation losses from process sewers, API separators, dissolved air flotation units, tailings ponds and storage tanks. Some countries currently classify several of these activities as fugitive emission sources. In other cases it is not clear whether they are accounted for at all.
Potential Key Issues:	Evaluating the reliability and completeness of total waste gas volumes reported to be vented or flared, the actual split between venting and flaring, and the assumed efficiency of flaring. Avoiding confusion due to potential differences in terminology, design and operating practices, and the reporting basis of activity data between Parties. Distinguishing between missed or underestimated emissions, and the impact of control measures implemented by the Party. Identifying classification of emissions (e.g., reporting fugitive emissions from oil transport under oil production). Apportioning between oil related emissions and gas related emissions in the upstream oil and gas industry can be difficult, resulting in inconsistent categorization of emissions across the category. Evaluating the basis for the assumptions and approximations made. Determining the degree to which a Party's methodology and QA/QC protocols are actually implemented. This may best be evaluated through in-country reviews.
General References	UNFCCC Common Reporting Format (Table 1.B.2, page 37 of FCCC/SBSTA/2004/8) IPCC Guidelines – Workbook (Module 1.5 – pages 1.24 to 1.26 and 1.70) IPCC Guidelines – Reference Manual (Volume 3, Chapter 1.7, pages 1.99 to 1.113) GPG (Chapter 2.7, pages 2.79 to 2.93)

Source Category		**1.B.2.c Venting and Flaring - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4, CO_2 and N_2O.	What IPCC methodology tier or other method has been applied, and is this consistent with good practice? Check that the stated method has in fact been applied.	The applicable methodology decision trees for assessing venting and flaring emissions are presented in Figures 2.12 to 2.14 in the GPG. In general, emissions should be evaluated using the best information available. Where sources are key sources to the Party's national GHG emissions, a Tier-3 method should be applied. For oil and gas systems a Tier-3 method is a rigorous bottom-up assessment approach, involving the development of detailed source counts coupled with the use of emission factors, production statistics and possibly some source modeling and measurement data. In most cases, it is likely that a combination of approaches have been used to assess venting and flaring emissions from the different stages of each system. If the emissions reported for a source or

			sub-source have been determined based on a roll-up of inventories from individual companies, all companies should have utilized a common methodology. If they have not, the differences between them and their corresponding impacts should be documented.
Emission Factor	CH_4, CO_2 and N_2O.	Check that good practice has been used in selecting the emission factors.	Refer to Section 2.7.1.2 (pages 2.84 to 2.87) of the GPG.
		Check that the selected emission factors are within the range of values provided in the IPCC Guidelines, or that departures from this are adequately justified. Also, confirm that the emission factors either are expressed using the same units of measure and reference conditions as the activity data, or that appropriate conversion factors have been applied.	The potential range in Tier-1 CH_4 emission factors is given in Tables 1-57 and 1-58 of the IPCC Guidelines. Table 2.16 of the GPG presents typical factors for fugitive CO_2 and N_2O emissions from oil and gas systems in the United States and Canada. Information indicating typical ranges in these values is not available; however, it is reasonable to expect implied emission factors generally to be within an order of magnitude of these values.
		Check that the assumed flaring efficiency based on the results in Table 1.B.2.c of the CRF is reasonable.	Under ideal conditions, a combustion efficiency of 98 percent may be achieved for flares and 99 percent for incinerators (U.S. EPA, 1995). However, in cases involving high-velocity flaring events, strong cross-winds, flame stability problems, or flaring of rich/condensing streams such as associated and solution gas, the efficiencies could be appreciably less.
Activity Data	CH_4, CO_2 and N_2O.	Check that appropriate activity data are being applied.	The required activity data depends on the part of the system being considered and the emission assessment method used, as summarized in Table 2.17 of the GPG (page 2.89).
		Compare the reported activity data against corresponding values published by international agencies.	Refer to the glossary of key oil and gas related terminology following this section. Note that some venting and flaring statistics do not differentiate between acid-gas flaring and other waste-gas flaring. Acid gas streams are a by-product of the sweetening process at sour gas processing plants and refineries, and may contain large amounts of raw CO_2 extracted from the process gas (typically, from 20 to 95 mole percent CO_2). The rest of the acid gas tends to be mostly H_2S. The amount of acid gas production is usually metered; although not typically tracked by regulatory agencies, the CO_2 content is known by the facility operators.

			Depending on the raw CO_2 content, the net emissions of CO_2 per unit volume of acid gas flared may be appreciably less than for typical waste gas streams. If the acid gas is processed by a sulphur recovery unit rather than being flared, the raw CO_2 passes through the process and is discharged out the final tail gas incinerator, and is not reported in the available statistics as either vented or flared gas.
		Do the reported activity data correctly distinguish between venting and flaring, or are the two activities reported as an aggregate value? In the latter case, check that a reasonable basis for estimating the split between vented and flared volumes has been used.	Typically, waste gas is flared if it contains hydrogen sulphide or if it is in a populated area and there is an odor potential; otherwise it is vented, since this can be done safely and is a more economical option. This general rule may be used to infer disposal practices at oil and gas facilities, but usually requires an intimate knowledge of the Party's oil and gas industry. In the absence of such information, as a conservative first approximation it should be assumed that all waste gas is vented. Venting rather than flaring is common practice at gas transmission and storage facilities.
		Check that good practice has been followed for collection of the activity data.	Refer to Section 2.7.1.3 (page 2.88 to 2.90) of the GPG.
Completeness	CH_4, CO_2 and N_2O.	Check that all applicable subcategories and sub-sources have been fully addressed. If not, evaluate whether the omitted subcategories and sub-sources are likely to be key sources on the basis of the reviewer's judgment	Refer to Section 2.7.1.4 (pages 2.90 to 2.91) of the GPG. The different subcategories that may apply are summarized in Table 2.15 of the GPG (page 2.83).
		Check that emissions of all applicable gases are fully accounted for, and that any omissions or simplifications are reasonable on the basis of the reviewer's judgment.	Venting and flaring emissions from oil and gas systems should normally comprise CH_4, CO_2 and N_2O. CH_4 should be the dominant GHG emitted by most non-combustion sources, and CO_2 should be the dominant GHG emitted due to flaring of waste gases and venting or flaring of acid gas streams at gas processing plants. A small amount of N_2O and some unburned CH_4 emissions is associated with all flaring activities. The amount of unburned CH_4 from flaring will depend on the assumed flaring efficiency. CO_2 emissions may also occur due to the venting of CO_2 removed from raw natural gas at gas processing plants. The amount of naturally occurring CO_2 depends on the reservoir and sometimes on the type of production techniques employed, but

			generally increases with the depth of the reservoir.
Recalculations/Consistent Time Series	CH_4, CO_2 and N_2O.	Check that good practice has been used to maintain consistent time series.	Refer to Section 2.7.1.5 (page 2.91) and Section 7.3 (pages 7.13 to 7.21) of the GPG.
Uncertainty	CH_4, CO_2 and N_2O.	Check that the Party has estimated the uncertainty in its reported emissions, and that the selected method is consistent with good practice.	The Party should be evaluating the uncertainty in their emission estimates. The values should be based on a 95-percent confidence interval. Refer to Section 2.7.1.6 (pages 2.91 to 2.92) and Section 6 (pages 6.1 to 6.34) of the GPG.
Reporting and Documentation	CH_4, CO_2 and N_2O.	Check that the Party has used good practice in reporting and documenting its emissions inventory.	Refer to Section 2.7.2 (pages 2.92 to 2.93) of the GPG.
QA/QC	CH_4, CO_2 and N_2O.	Check that good practice has been used to help ensure completeness and to avoid any double counting or omission of data.	Refer to Section 2.7.3 (page 2.93) and Section 8 (pages 8.1 to 8.17) of the GPG. Problems are likely to arise due to the need to make assumptions to bridge certain data gaps, difficulties with separating out vented and flared volumes, and high uncertainties in reported vented/flared volumes.

Oil and Natural Gas System Flow Diagrams

The following figures present high-level schematic flow diagrams showing the key elements of oil and natural gas systems in moving from the wellhead to the final consumer. These diagrams should be used in combination with the lists of facility types defined in the Glossary of Oil and Gas Related Terminology following this section to help interpret and assess the completeness of a Party's assessment of fugitive emissions from its oil and gas industry.

The complete oil system is shown on Figure 1. The natural gas system is divided into three parts: production and processing, transmission and storage, and distribution (Figure 2, Figure 3, and Figure 4, respectively). Not all oil and gas systems will necessarily have all of the elements shown, and where an element occurs it may not necessarily have all the major equipment types listed. Other equipment types not listed that may be associated with each element include: inlet headers, miscellaneous yard piping and valving, sampling connections, future tie-in points, test connections, chemical injection points, instrumentation, monitoring ports, bypass systems, isolation valves, drains, fuel systems, drip pots, scrubbers, etc.

FIGURE 1 - CRUDE OIL SYSTEM

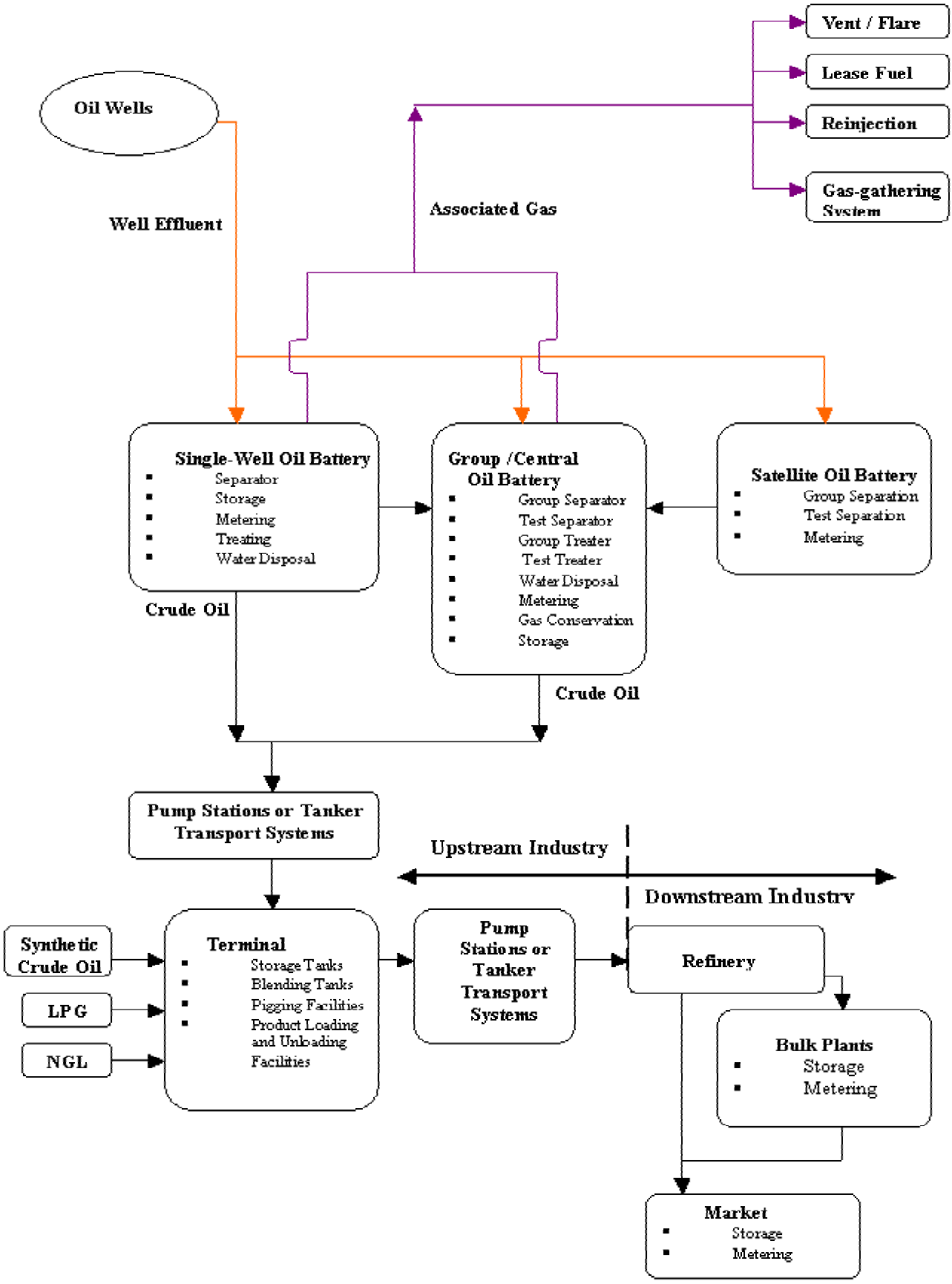


FIGURE 2 - GAS PRODUCTION SYSTEM

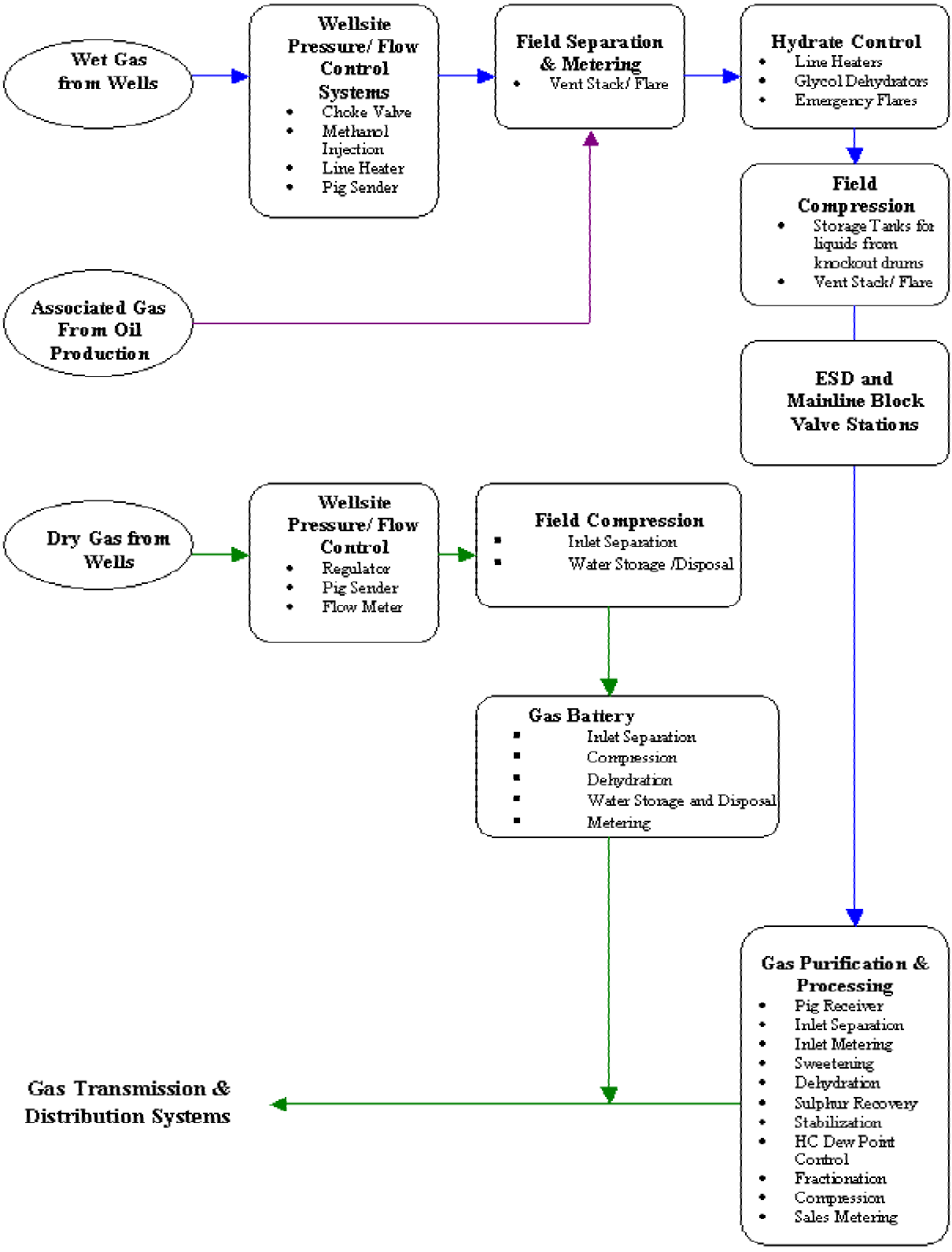


FIGURE 3 - GAS TRANSMISSION & STORAGE SYSTEM

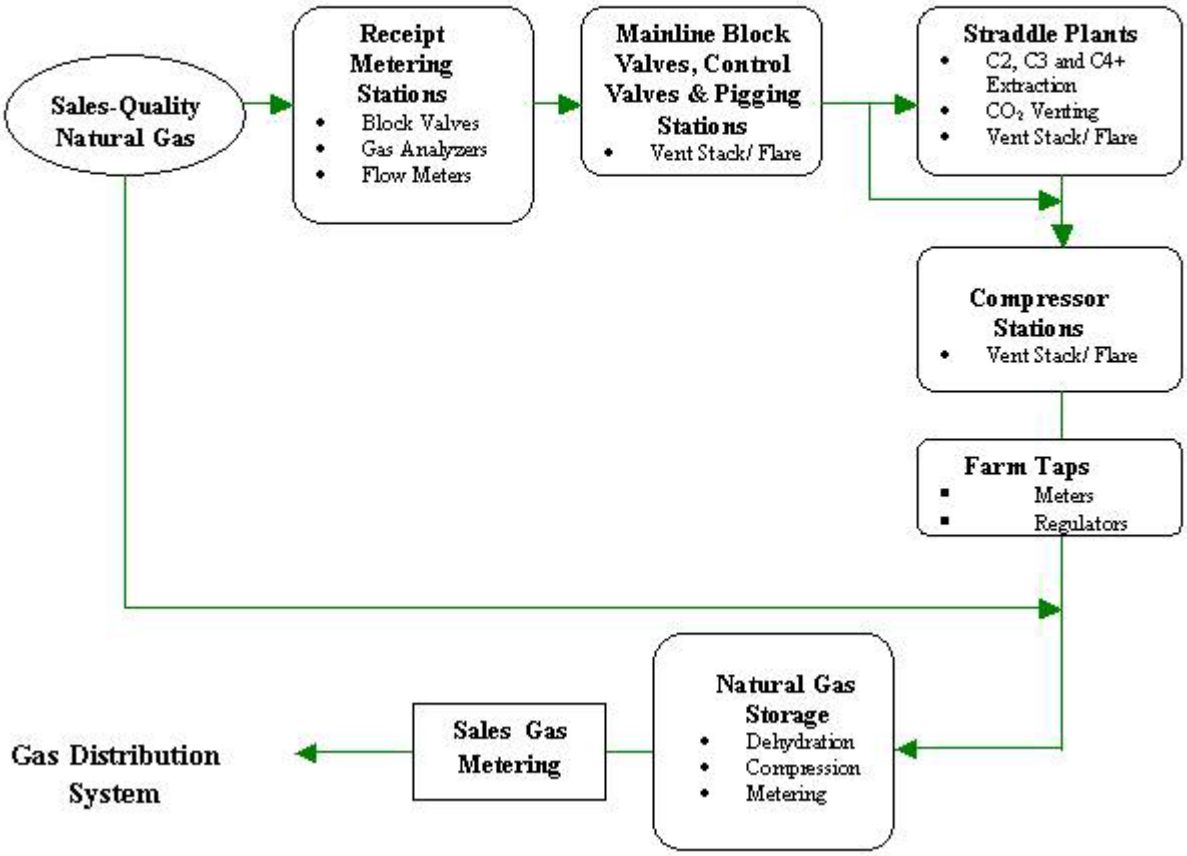
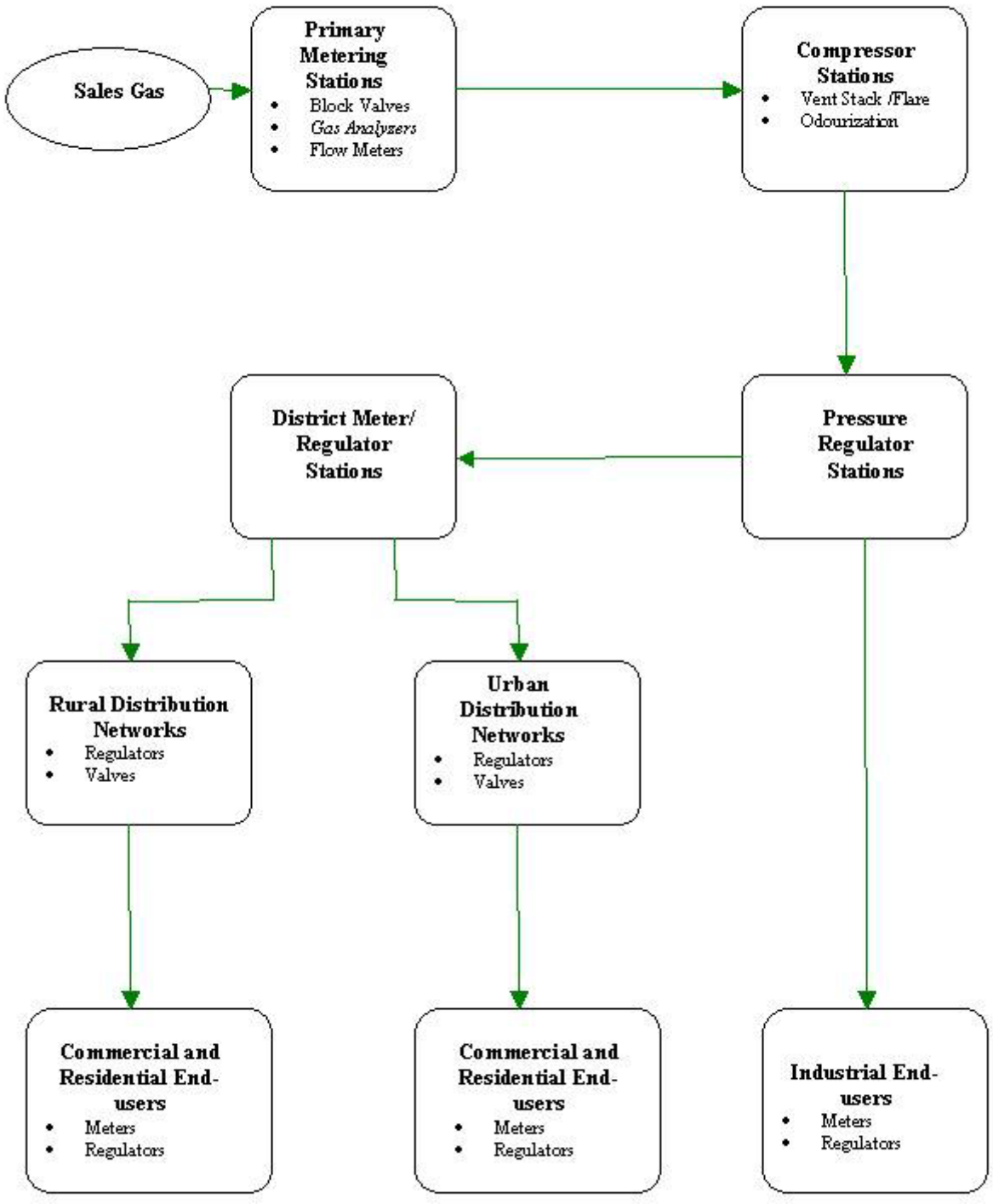


FIGURE 4 - GAS DISTRIBUTION SYSTEM



Glossary of Oil and Gas Related Terminology

This glossary is organized into four main categories:

- Oil and Gas Facility Terminology,
- Oil and Gas Statistical Terminology,
- Equipment Terminology, and
- Emissions Terminology.

The Oil and Gas Facility Terminology category is further subdivided into:

- Wells,
- Oil Facilities,
- Gas Production and Processing Facilities,
- Gas Transmission and Storage Facilities, and
- Gas Distribution Facilities.

The presented terms and their definitions have been adapted from a wide variety of sources, including American Petroleum Institute, US Environmental Protection Agency, Canadian Gas Association, Alberta Environment, Alberta Energy and Utilities Board, oil and gas producers and equipment manufacturers. They are intended to assist in the general interpretation and understanding of emission estimates for the oil and gas industry.

Oil And Gas Facility Terminology

Wells

Abandoned Well - a well that has been drilled, abandoned, cut, and capped at surface.

Blowout - the complete loss of control of the flow of fluids from a well to the atmosphere or the flow of fluids from one underground reservoir to another (an underground blowout). Wellbore fluids are released uncontrolled at or near the wellbore. Well control can only be regained by installing or replacing equipment to shut in or kill the well or by drilling a relief well.

Cyclical Well - a crude bitumen well requiring steam to be injected to produce the hydrocarbons. The steaming and producing are performed in alternating cycles.

Development Well – a well drilled within the proved area of an oil or gas reservoir to the depth of a stratigraphic horizon known to be productive. If the well is completed for production, it is classified as an oil or gas development well. If the well is not completed for production, it is classified as a dry development hole.

Disposal Well - a well used for the disposal of any oilfield or processing waste fluids or produced water into a reservoir or aquifer.

Dry hole – an exploratory or development well found to be incapable of producing either oil or gas in sufficient quantities to justify completion as an oil or gas well.

Farm Well - a well used to supply hydrocarbons or water to a farm for utility purposes.

Flowing Well - a well capable of producing fluids to surface through natural reservoir drive mechanisms, usually formation pressure.

Gas Lift Well - a well producing fluids into the tubing/annulus with the assistance of injected gas alone or in conjunction with mechanical equipment.

Industrial Well - a well used for the disposal of processing wastes from a refinery or chemical plant or brine from preparation or operation of a storage cavern.

Injection Well - a well used primarily to inject fluids into a reservoir as part of an enhanced recovery, experimental, or pilot scheme.

Observation Well - a well used to monitor performance in an oil or gas reservoir, oil sands deposit, or aquifer.

Offshore well - a well that is bottomed at, or produces from a point that lies seaward of the coastline.

Production Well - any hole drilled in the earth from which crude oil, condensate, or field natural gas is extracted.

Producing Well - a well producing hydrocarbons from a reservoir or oil sands deposit.

Pumping Well - a well producing fluids with the assistance of mechanical equipment (e.g., pump jack or downhole pump) to lift fluids to the surface.

Service Well – a well drilled or completed for the purpose of supporting production in an existing field. Wells of this class are drilled for the following specific purposes:

- Gas injection (natural gas, propane, butane or flue-gas)
- Water injection
- Steam injection
- Air injection
- Salt water injection
- Water supply for injection
- Observation
- Injection for in-situ combustion

Shut-in Well - a well that has been completed but is not producing. A well may be shut-in for tests, repairs, to await construction of gathering or flow lines, or better economic conditions.

Steam-Assisted Gravity Drain (SAGD) Well - a well used to produce heavy oil with the assistance of thermal heating by steam.

Storage Well - a well used to inject hydrocarbons into a storage reservoir or cavern.

Sub-sea Wellhead - a wellhead installed on the sea floor and controlled remotely from a platform, a floating production facility or land.

Suspended Well - a well in which production or injection operations have ceased for an indefinite period of time.

Well - a hole drilled in the earth for the purpose of (1) finding or producing crude oil or natural gas; or (2) providing services related to the production of crude oil or natural gas.

Wellhead - the equipment fitted to the top of a well casing to maintain surface control of the well (i.e., outlets, valves, blowout preventers, etc).

Well Test - a flow test conducted to determine the deliverability of a well. Sometimes the test may be conducted into a flow or gathering line; however, more often the liquids are produced into temporary tankage brought on site for the test, and the gas phase is either vented or flared.

Workovers or Well Servicing - work performed on a well after its initial completion to repair downhole equipment or to increase production rates.

Oil Facilities

Central Oil Treating Plant - a battery system or arrangements of tanks or other surface equipment without any directly associated wells.

Crude Bitumen Group Battery - a production facility consisting of two or more flow-lined heavy oil/crude bitumen wells having individual separation and measuring equipment but with all equipment sharing a common surface location.

Crude Bitumen Proration Battery - a production facility consisting of two or more flow-lined heavy oil/crude bitumen wells having common separation and measuring equipment. Total production is prorated to each well based on individual well tests. Individual well production tests can occur at the central site or at remote satellite facilities.

Crude Bitumen Single Battery - a production facility for a single heavy oil/crude bitumen well or a single zone of a multiple completion heavy oil/crude bitumen well.

Crude Oil Group Battery - a production facility consisting of two or more flow-lined oil wells having individual separation and measurement equipment but with all equipment sharing a common surface location.

Crude Oil Proration (or Fieldgate) Battery - a production facility consisting of two or more flow-lined oil wells having common separation and measuring equipment. Total production is prorated to each well based on individual well tests. Individual well production tests can occur at the central site or at remote satellite facilities.

Crude Oil Single Battery - a production facility for a single oil well or a single zone of a multiple completion oil well.

Custom Treating Plant - a system or arrangement of tanks and other surface equipment receiving oil/water emulsion exclusively by truck for separation prior to delivery to market or other disposition.

High Vapour Pressure Pipeline - a pipeline system containing hydrocarbon mixtures in the liquid or quasi-liquid state with a vapour pressure greater than 110 kPa absolute at 38ºC. Some examples are liquid ethane, ethylene, propane, butanes, and pentanes.

Injection/Disposal Facility - a facility that is constructed and operated for the purpose of moving product(s) into a reservoir.

Marine Terminal – a system or arrangement of tanks and other surface equipment for receiving oil from, or transferring oil to, marine tankers.

Oil Battery - a system or arrangement of tanks or other surface equipment receiving primarily oil or bitumen from one or more wells prior to delivery to market or other disposition. An oil battery may include equipment for measurement, for separating inlet streams into oil, gas, and/or water phases, for cleaning and treating the oil, for disposal of the water, and for conservation of the produced gas. A tank battery may or may not include a glycol dehydration unit and compressor.

Oil Sands Extraction Plant - a facility for extracting crude bitumen from oil sands. Both thermal or physical extraction techniques are available. The physical extraction techniques comprise either (1) oil sands conditioning using rotary breakers and agitation tanks, and a tertiary or recovery scheme, or (2) a low-temperature raw bitumen pipeline, and thickeners and clarifiers.

Petroleum Bulk Terminals – all storage facilities operated by refining, pipeline, and bulk terminal companies which (1) receive their principal products by tankers, barges, or pipelines, or (2) have a total combined capacity of 8 000 m^3 (50,000 barrels) or more, regardless of the transportation means by which products are received.

Petroleum Refinery - a complex installation of equipment designed to manufacture finished petroleum products and feedstocks for other processes from crude oil and other liquid hydrocarbons with processing involving more than mechanical blending.

Production Platform - a platform from which development wells are drilled, and that carries all the associated processing plants and other equipment needed to maintain a field in production

Pipeline Terminal – a system or arrangement of tanks and other surface equipment principally for receiving oil from, and transferring oil to, pipelines. The terminal may also feature facilities for blending hydrocarbon liquids, and loading and unloading facilities for tank trucks and/or tank rail cars.

Pumping Station - a system of equipment located at intervals along a main pipeline to maintain flow to the terminal point.

Satellite or Satellite Battery - a small group of surface equipment (not including storage tanks) located between a number of wells and the main battery that is intended to separate and measure the production from each well, after which the fluids are recombined and piped to the main battery for treating and storage or delivery.

Tank Farm - a system or arrangement of tanks or other surface equipment associated with the operation of a pipeline that may include measurement equipment and line heaters, but does not include separation equipment or storage vessels at a battery.

Terminal – a plant and equipment designed to process crude oil or gas to remove impurities and water.

Truck Terminal - a system or arrangement of tanks and other surface equipment receiving crude oil by truck for the purpose of delivering crude oil into a pipeline.

Upgrader - a facility that converts bitumen and heavy crude oil into synthetic crude oil (SCO), which has a density and viscosity similar to conventional light-medium crude oil. Upgraders chemically add hydrogen to bitumen, subtract carbon from it, or both. In upgrading processes, essentially all the sulphur contained in bitumen (either in elemental form or as a constituent of oil sands coke) is removed.

Gas Production and Processing Facilities

Compressor Station/Site - service equipment intended to maintain or increase the flowing pressure of the gas that it receives from a well, battery, or gathering system prior to delivery to market or other disposition.

Emergency Shutdown (ESD) Valve Station - a valve installed on a pipeline, which will automatically close when the line pressure drops below critical a predetermined value. There purpose is to minimize the amount of gas released in the event of a line break. ESD valve stations are most commonly used on sour gas gathering systems.

Field Dehydrator - a dehydration unit located upstream of a gas processing plant or gas battery to control hydrates rather than provide any final treatment to meet sales specifications.

Field Facility - an installation designed for one or more specific limited functions. Such facilities usually process natural gas produced from more than one lease for the purpose of recovering condensate from the stream of natural gas; however, some field facilities are designed to recover propane, butane, natural gasoline, etc., and to control the quality of the natural gas to be marketed. Field facilities include compressors, dehydration units, field extraction units, scrubbers, drip points, conventional single or multiple stage separation units, low temperature separators, and other types of separation and recovery equipment.

Gas Gathering System - a facility consisting of gas lines used to move products from one facility to another. The facility may also include compressors and/or line heaters.

Gas Battery - a system or arrangement of surface equipment that receives primarily gas from one or more wells prior to delivery to a gas gathering system, to market, or to other disposition. Gas batteries may include equipment for measurement and for separating inlet streams into gas, hydrocarbon liquid, and/or water phases.

Gas Plant - a gas processing facility for extracting from gas helium, ethane, or natural gas liquids, or for the fractionation of mixed NGL to natural gas products, or a combination of both. A gas plant may also include gas purification processes for upgrading the quality of the gas to be marketed to meet contract specifications (i.e., for removing contaminants such as H_2O, H_2S, CO_2, and possibly adjusting the heating value by the addition or removal of N_2). The inlet natural gas may or may not have been processed through lease separators and field facilities.

Gas Single Battery - a production facility for a single gas well where production is measured at the wellhead. Production is delivered directly and is not combined with production from other wells prior to delivery to a gas plant, gas gathering system, or other disposition.

Gas Test Battery - a production facility for a gas well testing gas production prior to commencement of regular production.

Lease Separator - a facility located at the surface for the purpose of separating casinghead gas from produced crude oil and water at the temperature and pressure conditions of the separator.

Production Platform - a platform from which development wells are drilled and that carries all the associated processing plants and other equipment needed to maintain a field in production.

Gas Transmission and Storage Facilities

Block Valve Station - a block valve used to isolate a segment of the main pipeline for tie-in or maintenance purposes. On gas transmission systems, block valves are typically located at distances of 25 to 80 km along each line to limit the amount of piping that may need to be depressurized for tie-ins and maintenance, and to reduce the amount of gas that would be lost in the event of a line break.

Booster Station - a facility where gas pressure is increased to overcome friction losses through a pipeline. Centrifugal or axial-flow compressors are most commonly used in these applications. A station typically comprises several units in series or parallel, as well as the necessary suction and discharge piping. Many booster stations also have discharge coolers to reduce the viscosity of the compressed gas and thereby increase the efficiency of gas transmission.
Border Meter Station - a meter station where custody of the gas is transferred from one gas transmission system to another at a provincial or national boundary. These stations are usually larger than normal meter stations. Typically, they have 10 to 20 large diameter meter runs (16 to 20 NPS lines) and no pressure regulation.

Compressor Station - a facility where gas pressure is increased to allow the gas to enter into a higher pressure pipeline system (i.e., feed rather than booster service). Both centrifugal and reciprocating compressor units may be used in these applications. However, use of reciprocating compressors is most common. A station typically comprises several units in series or parallel, as well as the necessary suction and discharge piping. Many compressors also have discharge coolers to reduce the viscosity of the compressed gas and thereby increase the efficiency of gas transmission.

Control Valve Station - a modulating valve that controls either the flow rate or pressure through the pipeline. In the latter case, this facility is often referred to as a regulator station. Usually, high-pressure gas from the pipeline is used as the supply medium needed to energize the valve actuator.

Receipt Meter Station - a meter station for measuring the amount of gas being supplied by a given source (e.g., gas processing plant or a gas battery) to a gas transmission system.

Sales Meter Station - a meter station for measuring the amount of gas being withdrawn from a gas transmission system by a customer (e.g., gas distribution system, farm or industrial end user). It may include pressure-regulating equipment.

Storage - most transmission systems incorporate the use of storage caverns or spheres to help balance daily and seasonal variations in loads, enabling them to operate at nearly full capacity much of the time.

Straddle Extraction Plant - a gas processing plant located on or near a gas transmission line that removes natural gas liquids from the gas and returns the residue gas to the line.

Transmission Farm Tap - direct gas sales from a transmission pipeline to an individual customer, usually in rural areas where access to gas distribution system is not available. These facilities usually have only pressure regulating equipment (gas might be provided free of charge as a consideration for an easement, or the meter is located by the residence as part of the customer meter set).

Transmission Pipeline - a pipeline used to transport processed, unodourized natural gas to market (i.e., to gas distribution systems and major industrial customers). Most transmission pipelines also have some farm taps that provide gas to farmers located along the pipeline in areas where service from distribution systems is not readily available.

The pipelines are usually constructed of steel, although aluminum is used for some lower pressure applications (generally up to 3450 kPa or 500 psig). The pipe sizes range from 60.3 mm to 1219.2

mm O.D. (2 to 48 NPS), with the mid-range sizes most common. The operating pressures typically range from 1380 to over 6900 kPa_g (200 to 1000+ psig).

Transmission Stations - are stations associated with transmission pipelines that handle unodourized gas. They meter and/or regulate the gas pressure. They include Receipt/Sales Stations, Border Meter Stations and Transmission Farm Taps.

Gas Distribution Facilities

Cast-Iron Pipelines - pipelines made of cast iron.

Commercial Meter Set - customer metering facilities for gas sales to a commercial customer. They include both pressure regulation and measurement. The regulator reduces the pressure from distribution pressure to 1.7 kPa_g (0.25 psig) or often a higher pressure, typically not in excess of 140 kPa_g (20 psig).

Copper-Tubing Service Lines - service lines made of copper tubing. Copper-tubing typically has not been used for new construction since at least the 1960s.

Gate Station - a distribution facility located adjacent to a transmission facility where gas is odourized and flows through a splitter system for distribution to different districts or areas. The inlet gas is often metered, heated, and the pressure reduced. These stations may have multiple metering and pressure regulating runs.

Distribution Farm Tap - a small pressure regulating station located in rural or semi-rural areas on high-pressure pipelines flowing odourized gas. It usually only regulates the pressure down to a distribution pressure, and often does not include metering equipment.

Distribution Mains - distribution mains deliver odourized gas to the customers. They range in size from 26.7 mm OD (¾ NPS) in rural distribution to 609.6 mm OD (24 NPS), with the most common being 60.3 to 219.1 mm OD (2 to 8 NPS). Systems constructed of plastic pipe (mostly polyethylene, but also P.V.C. or some other plastics) are typically operated at pressures of up to 690 kPa_g (100 psig), although there are polyethylene resins that allow operation at pressures slightly over 700 kPa_g (100 psig). Higher-pressure steel pipelines (either with or without cathodic protection) flowing odourized gas are considered distribution mains. A few older systems constructed of cast iron also exist.

Distribution Stations - stations associated with the distribution mains that handle odourized natural gas. By function, they include gate stations, district regulating stations, distribution farm taps and industrial meter sets.

District Regulating Stations - a secondary regulating facility located downstream of a gate station on gas distribution systems where gas pressure is further reduced (usually to about 400 kPa_g [60 psig] but sometimes only to 1200 kPa_g [175 psig], depending on the company).

Industrial Meter Set - a metering facility that transfers gas from the distribution system to a large industrial customer. Typically, gas is supplied at intermediate or high pressure (400 to 3000 kPa_g [60 to 435 psig] or more), and is metered and pressure regulated.

Miscellaneous Pipeline Equipment - aboveground or exposed equipment components (e.g., isolation/block valves, pressure-relief valves, connectors, etc.) used on the pipeline that do not occur at an actual distribution station. Buried components are deemed to be part of the piping.

Plastic Pipelines - pipelines made of various types of plastic, including polyethylene, polyvinyl chloride, ABS, etc.

Protected Steel Pipelines - steel pipelines that are cathodically protected.

Residential Meter Set - customer metering facilities for gas sales to a residential customer. They include both pressure regulation and measurement. The regulator typically reduces pressure from distribution pressure to 1.7 kPa_g (0.25 psig).

Service Lines - usually a short, small diameter pipeline that delivers gas from a distribution main or transmission pipeline to the customer. They are usually made of steel pipe or steel tubing (either cathodically protected or not), or plastic (usually polyethylene, but sometimes PVC or other plastic), although copper tubing was also sometimes used in the past.

Sizes vary from 21.3 to 60.3 mm OD (½ to 2 NPS), with some commercial or industrial customers having service lines of much larger diameter.

Service lines tied into transmission lines might operate at pressures exceeding the distribution pressure. They are called “high-pressure service lines," and require double regulation at the customer meter set. Typically, they operate at pressures above 860 kPa_g (125 psig).

Unprotected Steel Pipelines - steel pipelines that are not cathodically protected.

Oil And Gas Statistical Terminology

Abandonment - the permanent dismantlement of a facility so that it is permanently incapable of its original intended use. This includes leaving downhole or subsurface structures in a permanently safe and stable condition; the removal of associated equipment and structures; the removal of all produced liquids; and the removal and appropriate disposal of structural concrete.

Acid Gas - gas that contains hydrogen sulphide (H_2S), total reduced sulphur compounds, and/or carbon dioxide (CO_2) that is separated in the treating of solution or non-associated gas.

API Gravity - the weight per unit volume of hydrocarbon liquids as measured by a system recommended by the American Petroleum Institute (API). The measuring scale is calibrated in terms of degrees API. API Gravity is the industry standard for expressing the specific gravity of crude oils. A high API gravity means lower specific gravity and lighter oils.

Associated Gas - gas that is produced from an oil or bitumen pool. This may apply to gas produced from a gas cap or in conjunction with oil or bitumen.

Black Oil - hydrocarbon (petroleum) liquid with an initial producing gas-to-oil ratio (GOR) less than 0.31 cubic meters per liter and an API gravity less than 40 degrees.

Casinghead Gas - dissolved gas and associated gas may be produced concurrently from the same well bore. In such situations, it is not feasible to measure the production of dissolved gas and associated gas separately; therefore, production is reported as casinghead gas. Sometime it may simply be referred to as either associated gas or solution gas.

Coke - a high carbon content solid residue from an oil refinery or upgrader process, which can be used as a boiler fuel to produce steam and electric power.

Compressed Natural Gas (CNG) - natural gas compressed into high-pressure fuel cylinders to power a car or truck. It comes from special CNG fuel stations.

Condensate – hydrocarbon liquid separated from natural gas that condenses due to changes in the temperature, pressure, or both, and remains liquid at standard conditions.

Custody Transfer Point - the transfer of hydrocarbon liquids or natural gas, after processing and/or treatment in the producing operations or from storage vessels, automatic transfer facilities or other such equipment, including product loading racks, to pipelines or any other forms of transportation.

Crude Bitumen - a naturally occurring viscous mixture consisting of hydrocarbons heavier than pentane with other contaminants, such as sulphur compounds, which in its natural state will not flow.

Crude Oil - a mixture of hydrocarbons that exist in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separation facilities.

Crude Oil, Losses - the volume of crude oil (including lease condensate) reported by petroleum refineries, pipelines and lease holders as being lost or unaccounted for in their operations. These losses are of a non-processing nature (i.e., losses due to spills, contamination, fires, etc.), as opposed to refinery processing losses or gains.

Crude Oil, Refinery Input - total crude oil (domestic plus foreign), including lease condensate, input to crude oil distillation units, plus crude oil input to other refinery processing units (cokers, etc.).

Total refinery input means the sum of (1) all crude oil (including pentanes plus); (2) products of natural gas processing plants (including plant condensate); (3) unfinished oils rerun during the period less those unfinished oils produced; (4) other hydrocarbons such as shale oil, gilsonite, and tar sands oils; (5) natural gas received for reforming into hydrogen but not natural gas used as refinery fuel; (7) hydrogen; (8) alcohol; and (9) any other hydrocarbons or other liquids processed or blended by mechanical means at a refinery.

Crude Oil, Refinery Receipts – receipts of domestic and foreign crude oil (including lease condensate) at a refinery, to include all in-transit volumes except in-transit by pipeline. Foreign crude oil is reported as received only after entry through customs. Crude oil of foreign origin in-transit, or held in bond, is excluded.

Diluents - are light petroleum liquids used to dilute bitumen and heavy oil so they can flow through pipelines.

Dissolved Gas - natural gas that is in solution with crude oil in the reservoir at reservoir conditions.

Dry Natural Gas - field gas that does not require any processing to meet contract hydrocarbon dew point requirements.

Emulsion - a combination of two immiscible liquids, or liquids that do not mix together under normal conditions.

Extraction Loss (or Shrinkage) - the reduction in volume of natural gas resulting from the removal of the natural gas liquid constituents of natural gas at the processing plant.

Field - an area consisting of a single reservoir or multiple reservoirs all grouped on, or related to, the same individual geological structural feature and/or stratigraphic condition. There may be two or more reservoirs in a field that are separated vertically by intervening impervious strata, or laterally by local geologic barriers, or by both.

Field Natural Gas - natural gas extracted from a production well prior to entering the first stage of processing, such as dehydration.

Gas Cycling - a petroleum recovery process that takes produced gas and condensate and injects it back into the reservoir to increase pressure and increase the production of natural gas liquids.

Gas Injection - an enhanced recovery technique in which natural gas is compressed into a producing reservoir through an injection well to drive oil to the well bore and the surface.

Gas-to-Oil Ratio (GOR) - the number of standard cubic meters of gas produced per liter of crude oil or other hydrocarbon liquid.

Heavy Oil - a category of crude oil characterized by relatively high viscosity, a higher carbon-to-hydrogen ratio, a high proportion of bitumen, and heavier specific gravities (weights). Heavy oil typically has an API gravity of about 28º or less, is difficult to extract with conventional techniques and is more costly to refine.

High Vapor Pressure Hydrocarbon – any hydrocarbon and stabilized hydrocarbon mixture with a Reid vapor pressure greater than 14 kPa.

Liquefied Natural Gas (LNG) - natural gas that has been refrigerated to –160ºC to condense it into a liquid. The liquefaction process removes most of the water vapor, butane, propane, and other trace gases, that are usually included in ordinary natural gas. The resulting LNG is usually more than 98 percent pure methane.

Liquefied Petroleum Gas (LPG) - a natural gas mixture composed of mainly ethane, propane, and butanes, with small amounts of pentanes plus (C5+) in any combination. The fluid is usually gaseous under atmospheric conditions but becomes a liquid under pressure.

Methane Content of Natural Gas - the volume of methane contained in a unit volume of natural gas at 15°C 101.325 kPa.

Natural Gas - a naturally occurring mixture of hydrocarbon and non-hydrocarbon compounds existing in the gaseous phase or in solution with hydrocarbon liquids in geologic formations beneath the earth's surface. The principal hydrocarbon constituent is methane.

Natural Gas Liquids (NGL) - liquid hydrocarbons, such as ethane, propane, butane, pentane, natural gasoline, and condensate that are extracted from field natural gas.

Non-Associated Gas - gas that is produced from a gas pool (e.g., gas that is not associated with oil or bitumen reservoirs or production).

Oil - means crude oil both before and after it has been subjected to any refining or processing, any hydrocarbon recovered from crude oil, oil sands, natural gas or coal for transmission in a liquid state, and liquefied natural gas, and any other substance in association with that crude oil, hydrocarbon or liquefied natural gas.

Oil Sands - sands and other rock materials containing crude bitumen.

Offshore – refers to the geographic area that lies seaward of the coastline. In general, the term "coastline" means the line of ordinary low water along that portion of the coast that is in direct contact with open sea or the line marking the seaward limit of inland water.

Operator - a company appointed by venture stakeholders to take primary responsibility for day-to-day operations and activities for a specific plant or activity.

Petroleum - another word for crude oil.

Pentanes Plus – a mixture of hydrocarbons, mostly pentanes and heavier, extracted from natural gas. It includes natural gasoline, isopentane and plant condensate.

Pipeline Break - a rupture in any part of a pipeline.

Pipeline Fuel - natural gas consumed in the operation of a natural gas pipeline, primarily in compressors

Plant Condensate – one of the natural gas plant products, mostly pentanes and heavier, recovered and separated as liquids at the gas inlet separators or scrubbers in processing plants or field facilities.

Pool - is synonymous with the term reservoir; however, in certain situations, a pool may consist of more than one reservoir.

Produced Water - water that is extracted from the earth from an oil or natural gas production well, or that is separated from crude oil, condensate, or natural gas after extraction.

Reservoir - a porous and permeable underground formation containing an individual and separate natural accumulation of producible hydrocarbons (oil and/or gas) which is confined by impermeable rock or water barriers and is characterized by a single natural pressure system. In most situations, reservoirs are classified as oil reservoirs or as gas reservoirs by a regulatory agency. In the absence of a regulatory authority, the classification is based on the natural occurrence of the hydrocarbons in the reservoir as determined by the operator.

Refined Products - the marketable processed output of a petroleum refinery. Examples include naphtha, gasoline, kerosene, heating oil, diesel, lubricant base oils and asphalt.

Refinery Output – the total amount of petroleum products produced from refinery input in a given period, including those products produced and consumed by the refinery. This figure includes (1) sales or transfers of all finished products, including usage within the refinery for purposes other than fuel, (2) all internal consumption of finished or unfinished products as fuel, (3) plus/minus any additions/reductions to finished stock inventory. Non-petroleum additives are excluded.

Refinery Processing Gain – the volumetric amount by which total output is greater than input. This difference is due to the processing of crude oil into products that, in total, have lower specific gravity than the crude oil processed. Therefore, in terms of volume, the total output of products is greater than input.

Refinery Processing Loss – the volumetric amount by which total output is less than input for a given period of time. This difference is due to the processing of crude oil into products which, in total, have a higher specific gravity than the crude oil processed. Therefore, in terms of volume, the total output is smaller than the input. Physical losses also contribute (i.e., losses to flaring, atmosphere, etc.).

Residue Gas - natural gas from which gas plant products (natural gas liquids), and in some cases non-hydrocarbons, have been extracted in gas processing plants.

Shale Oil - oil produced from oil shale, a laminated, sedimentary rock that contains a solid, waxy hydrocarbon called kerogen which is commingled with the rock structure. Shale oil is the hydrocarbon substance produced from the decomposition of the kerogen when oil shale is heated in an

oxygen-free environment. Raw shale oil resembles a heavy, viscous, low-sulphur high-nitrogen crude but can be upgraded to produce a good-quality sweet crude.

Solution Gas - gas that is in solution with produced oil or bitumen.

Sour Oil – crude oil containing free sulphur, hydrogen sulphide or other sulphur compounds

Sour Gas - raw natural gas that contains quantities of hydrogen sulphide (H_2S), carbon dioxide (CO_2), and other sulphide-based compounds in sufficient quantities to pose a public safety hazard if released or to result in unacceptable off-lease odours if vented to the atmosphere.

Standard Reference Conditions - most equipment manufacturers reference flow, concentration and equipment performance data at ISO standard conditions of 15°C, 101.325 kPa, sea level and 0.0 percent relative humidity.

Stock Tank Vapors - the small volume of dissolved gas present in the oil storage tanks that may be released from the tanks.

Suspension - the cessation of normal production, operation, or injection activities at a facility.

Sweet Gas - raw natural gas with a relatively low concentration of sulphur compounds, such as hydrogen sulphide.

Synthetic Crude Oil - a mixture of hydrocarbons, similar to crude oil, derived by upgrading bitumen from oil sands.

Tar Sands Oil (or Crude Bitumen) -mixtures of liquid hydrocarbons derived wholly from bitumen-impregnated sands (or oil sands) which require further processing other than mechanical blending before becoming finished petroleum products.

Total Petroleum Stocks – the volume of crude oil (including lease condensate), natural gas plant liquids and petroleum products held by crude oil producers, storers of crude oil, companies transporting crude oil by water, crude oil pipeline companies, refining companies, product pipeline companies, and by bulk terminal companies. Included are domestic oil and foreign oil that have cleared customs for domestic consumption (i.e., foreign oil in-transit to the receiving country and foreign oils held in bonded storage, to include oils in the foreign trades zone, are excluded from these stock statistics). All stocks are reported on a custody basis, regardless of ownership of the oils.

Wet Natural Gas - field gas that needs to be processed to extract natural gas liquids in order to meet contract hydrocarbon dew point requirements.

Equipment Terminology

Ancillary Equipment - any of the following pieces of equipment: pumps, pressure relief devices, sampling connection systems, open-ended valves, or lines, valves, flanges, or other connectors.

Boiler - an enclosed device using controlled flame combustion and having the primary purpose of recovering and exporting thermal energy in the form of steam or hot water.

Centrifugal Compressor Seal Systems - Centrifugal compressors generally require shaft-end seals between the compressor and bearing housings. Either face-contact oil-lubricated mechanical seals or oil-ring shaft seals or dry-gas shaft seals are used. The amount of leakage from a given seal will tend to increase with wear between the seal and compressor shaft, operating pressure and rotational speed of the shaft.

Closed-Vent System - a system that is not open to the atmosphere and is composed of piping, ductwork, connections, and, if necessary, flow inducing devices that transport gas or vapour from an emission point to one or more control devices.

Combustion Device – an individual unit of equipment, such as a flare, incinerator, process heater, or boiler, used for the combustion of organic emissions.

Connectors – any flanged or threaded connection, or mechanical coupling, but excluding all welded or back-welded connections. If properly installed and maintained, a connector can provide essentially leak-free service for extended periods of time. However, there are many factors that can cause leakage problems to arise. Some of the common causes include vibration, thermal stress and cycles, dirty or damaged contact surfaces, incorrect sealing material, improper tightening, misalignment, and external abuse.

Control Device - any equipment used for recovering or oxidizing waste natural gas or VOC vapours. Such equipment includes, but is not limited to, absorbers, carbon adsorbers, condensers, incinerators, flares, boilers, and process heaters.

Cover - a device that is placed on top of, or over, a material such that the entire surface area of the material is enclosed and sealed. A cover may have openings (such as access hatches, sampling ports, and gauge wells) if those openings are necessary for operation, inspection, maintenance, or repair of the unit on which the cover is installed, provided that each opening is closed and sealed when the opening is not in use. In addition, a cover may have one or more safety devices. Examples of a cover include, but are not limited to, a fixed-roof installed on a tank, an external floating roof installed on a tank, and a lid installed on a drum or other container.

Flare and Vent Systems - venting and flaring are common methods of disposing of waste gas volumes at oil and gas facilities. The stacks are designed to provide safe atmospheric dispersion of the effluent. Flares are normally used where the waste gas contains odorous or toxic components (e.g., hydrogen sulphide). Otherwise the gas is usually vented. Typically, separate flare/vent systems are used for high- and low-pressure waste gas streams.

Incinerator - an enclosed combustion device that is used for destroying organic compounds. Auxiliary fuel may be used to heat waste gas to combustion temperatures. An energy recovery section is not physically formed into one manufactured or assembled unit with the combustion section; rather, the energy recovery section is a separate section following the combustion section and the two are joined by ducts or connections carrying flue gas. The above energy recovery section limitation does not apply to an energy recovery section used solely to preheat the incoming vent stream or combustion air.

Line Heater - an indirectly fired heater used to heat the fluid in the pipeline to above hydrate or freezing temperatures.

Direct-Fired Heater - the combustion gases occupy most of the heater volume and heat the process stream contained in pipes arranged in front of refractory walls (the radiant section) and in a bundle in the upper portion (the convective section). Convective heaters are a special application in which there is only a convective section.

Flare - an open flame used for routine or emergency disposal of waste gas. There are a variety of different types of flares including: flare pits, flare stacks, enclosed flares and ground flares.

Fixed Roof - a cover that is mounted on a storage vessel in a stationary manner and that does not move with fluctuations in liquid level.

Flow Indicator - a device that indicates whether gas flow is present in a line or whether the valve position would allow gas flow to be present in a line.

Fire-Tube Heaters - the combustion gases are contained in a fire-tube that is surrounded by a liquid that fills the heater shell. This liquid may be either the process stream or a heat medium that surrounds the coil bundle containing the process stream. Common applications are indirect-fired water-bath heaters (line heaters) and glycol reboilers.

Gas-Condensate-Glycol (GCG) Separator - a two- or three-phase separator through which the ‘‘rich’’ glycol stream of a glycol dehydration unit is passed to remove entrained gas and hydrocarbon liquid. The GCG separator is commonly referred to as a flash separator or flash tank.

Glycol Dehydration Unit - a device in which a liquid glycol including, but not limited to, ethylene glycol, diethylene glycol, or triethylene glycol absorbent directly contacts a natural gas stream and absorbs water in a contact tower or absorption column (absorber). The glycol contacts and absorbs water vapour and other gas stream constituents from the natural gas and becomes ‘‘rich’’ glycol. This glycol is then regenerated in the glycol dehydration unit reboiler. The ‘‘lean’’ glycol is then recycled.

Glycol Dehydration Unit Reboiler Vent - the vent through which exhaust from the reboiler of a glycol dehydration unit passes from the reboiler to the atmosphere or to a control device.

Integral Compressor - a reciprocating compressor that shares a common crankshaft and crankcase with the engine.

Open-Ended Valves and Lines - any valve that may release process fluids directly to the atmosphere in the event of leakage past the valve seat. The leakage may result from improper seating due to an obstruction or sludge accumulation, or because of a damaged or worn seat. An open-ended line is any segment of pipe that may be attached to such a valve and that opens to the atmosphere at the other end.

Few open-ended valves and lines are designed into process systems. However, actual numbers can be quite significant at some sites due to poor operating practices and various process modifications that may occur over time.

Some common examples of instances where this type of source may occur are:

- Scrubber
- Compressor-unit
- Station and mainline blowdown valves

- Supply-gas valve for a gas-operated engine starter (i.e., where natural gas is the supply medium)
- Instrument block valves where the instrument has been removed for repair or other reasons
- Purge or sampling points.

Pressure-Relief or Safety Valves - these are used to protect process piping and vessels from being accidentally over-pressured. They are spring loaded so that they are fully closed when the upstream pressure is below the set point, and only open when the set point is exceeded. Relief valves open in proportion to the amount of overpressure to provide modulated venting. Safety valves pop to a full-open position on activation.

When relief or safety valves reseat after having been activated, they often leak because the original tight seat is not regained either due to damage of the seating surface or a build-up of foreign material on the seat plug. As a result, they are often responsible for fugitive emissions. Another problem develops if the operating pressure is too close to the set pressure, causing the valve to "simmer" or "pop" at the set pressure.

Gas that leaks from a pressure-relief valve may be detected at the end of the vent pipe (or horn). Additionally, there is usually a monitoring port located on the bottom of the horn near the valve.

Process Heater - an enclosed device using a controlled flame, the primary purpose of which is to transfer heat to a process fluid or process material that is not a fluid, or to a heat transfer material for use in a process (rather than for steam generation).

Process Vessel - a heater, dehydrator, separator, treater, or any vessel used in the processing or treatment of produced gas or oil.

Pump Seals - positive displacement pumps are normally used for pumping hydrocarbon liquids at oil and gas facilities. Positive displacement pumps have a reciprocating piston, diaphragm or plunger, or else a rotary screw or gear.

Packing, with or without a sealant, is the simplest means of controlling leakage around the pump shaft. It may be used on both the rotating and reciprocating pumps. Specially designed packing materials are available for different types of service. The selected material is placed in a stuffing box and the packing gland is tightened to compress the packing around the shaft. All packings leak and generally require frequent gland tightening and periodic packing replacement.

Particulate contamination, overheating, seal wear, sliding seal leakage and vibration will contribute to increased leakage rates over time.

Reciprocating Compressor - a piece of equipment that increases the pressure of a process gas by positive displacement, employing linear movement of the drive shaft.

Reciprocating Compressor Packing Systems - are used on reciprocating compressors to control leakage around the piston rod on each cylinder. Conventional packing systems have always been prone to leaking a certain amount, even under the best of conditions. According to one manufacturer, leakage from within the cylinder or through any of the various vents will be on the order of 1.7 to 3.4 m^3/h under normal conditions and for most gases. However, these rates may increase rapidly as normal wear and degradation of the system occurs.

Relief Device - a device used only to release an unplanned, non-routine discharge in order to avoid safety hazards or equipment damage. A relief device discharge can result from an operator error, a malfunction such as a power failure or equipment failure, or other unexpected cause that requires

immediate venting of gas from process equipment in order to avoid safety hazards or equipment damage.

Safety Device - a device that meets both of the following conditions: it is not used for planned or routine venting of liquids, gases, or fumes from the unit or equipment on which the device is installed; and it remains in a closed, sealed position at all times except when an unplanned event requires that the device open for the purpose of preventing physical damage or permanent deformation of the unit or equipment on which the device is installed in accordance with good engineering and safety practices for handling flammable, combustible, explosive, or other hazardous materials. Examples of unplanned events which may require a safety device to open include failure of an essential equipment component or a sudden power outage.

Storage Vessel - a tank or other vessel that is designed to contain an accumulation of crude oil, condensate, intermediate hydrocarbon liquids, or produced water and that is constructed primarily of non-earthen materials (e.g., wood, concrete, steel, plastic) that provide structural support.

Storage Vessel with the Potential for Flash Emissions - any storage vessel that receives hydrocarbon liquids containing dissolved natural gas that will evolve from solution when the fluid pressure is reduced.

Tank - a device designed to contain materials produced, generated, and used by the petroleum industry that is constructed of impervious materials, such as concrete, plastic, fibreglass-reinforced plastic, or steel that provide structural support.

Turnaround - a scheduled large-scale maintenance activity wherein an entire process unit is taken offstream for an extended period for comprehensive revamp and renewal.

Valve - a device for controlling the flow of a fluid. There are three main locations on a typical valve where leakage may occur: (1) from the valve body and around the valve stem, (2) around the end connections, or (3) past the valve seat. Leaks of the first type are referred to as valve leaks. Emissions from the end connections are classified as connector leaks. Leakage past the valve seat is only a potential source of emissions if the valve, or any downstream piping, is open to the atmosphere. This is referred to as an open-ended valve or line.

The potential leak points on each of the different types of valves are, as applicable, around the valve stem, body seals (e.g., where the bonnet bolts to the valve body, retainer connections), body fittings (e.g., grease nipples, bleed ports), packing guide, and any monitoring ports on the stem packing system. Typically, the valve-stem packing is the most likely of these parts to leak.

The different valve types include gate, globe, butterfly, ball and plug. The first two types are a rising-stem design, and the rest are quarter-turn valves. Valves may either be equipped with a hand-wheel or lever for manual operations, or an actuator or motor for automated operation.

Emissions Terminology

Accidental Discharges - releases of oil, produced water, process chemicals and/or natural gas to the environment by human error, equipment malfunction, or a major equipment failure (e.g., pipeline break, well blow out, explosion, etc.).

Equipment Leaks - emissions of natural gas or hydrocarbon liquids from equipment components (i.e., valves, connectors, compressor seals, pump seals, pressure relief devices, and sampling systems).

Filling Losses - evaporation losses that occur during the filling of tank trucks, tanker rail cars and marine tankers.

Flaring Emissions - combustion products (e.g., CO_2, H_2O, SO_2 and N_2O) and products of incomplete combustion (e.g., CH_4 and VOCs) emitted by the flaring of waste gas volumes.

Fugitive Emissions - The sum of emissions from accidental discharges, equipment leaks, filling losses, flaring, pipeline leaks, storage losses, venting, flaring, and all other direct emissions except those from fuel use.

Pipeline Leak - fugitive emission through a small opening in the wall of the pipeline (e.g., due to corrosion or material defects) or from valves, fittings or connectors attached to that pipeline.

Storage Losses - working, breathing and flashing losses from storage tanks.

Vented Emissions - pollutant releases to the atmosphere by design or operational practice. They may occur on either a continuous or intermittent basis. The most common causes or sources of venting are gas operated devices that use natural gas as the supply medium (e.g., compressor start motors, chemical injection and odourization pumps, instrument control loops, valve actuators, and some types of glycol circulation pumps), equipment blowdowns and purging activities, and venting of still-column off-gas by glycol dehydrators.