IPIECA

# Methane glossary

Climate change

THE GLOBAL OIL AND GAS
INDUSTRY ASSOCIATION
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# Methane glossary

IPIECA

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# Contents

# Introduction

## METHANE IN CONTEXT

Natural gas can play an important role as part of the global energy mix in a lower-carbon future, provided that levels of methane emissions from the extraction, processing and transmission of natural gas to the end user are limited. Due to the relatively short-lived but potent warming effects understood to be associated with methane, there is increasing focus on actions by the oil and gas industry (as well as other sectors) to increase reporting and further reduce methane emissions.

To enhance understanding of these issues, IPIECA has undertaken a range of activities including:

- a workshop and report on short-lived climate forcers;
- a fact sheet entitled *Exploring methane emissions*; and
- a methane workshop, held jointly with the Oil and Gas Climate Initiative (OGCI), discussing the current gaps in knowledge, and considering data, studies and measurements from a wide range of oil and gas operations globally.

The objectives of this glossary are to support the industry and other stakeholders in the use of consistent terminology, and to improve confidence in understanding and managing methane emission sources to further improve performance in reducing methane emissions.

## ABOUT THE GLOSSARY

This glossary is part of IPIECA's efforts on the topic of methane emissions. It is intended to provide additional details for some of the key terms used within the methane discourse, and aims to provide a clear and consistent description of each term. The glossary details the technical information related to each term and, where deemed pertinent, provides additional contextual information (highlighted in *italics*) to further support a clear and consistent understanding of the term being described. The descriptions used in this text are based upon publicly available documentation, academic papers and industry experience.

Any scientific concepts and terms referred to in the glossary are not internal to IPIECA or its members unless otherwise specified.

The terms 'methane leakage', 'methane loss', 'methane emissions' and 'fugitives' are often used interchangeably to refer to methane emitted to the atmosphere from equipment, infrastructure and processes. There is often no differentiation between sources of methane emissions that are planned (e.g. gas pneumatics, tanks) and those that are unintentional (e.g. through joints, connections, etc.). Throughout this glossary the term 'methane emissions' will be used.

It should be noted that, throughout this document, the use of the term 'gas' refers to 'natural gas', unless specifically stated otherwise.

It is important to note that the type of gas asset or gas value chain is often a material factor in the presence or absence of methane emission sources, and will further impact the overall scale of methane emissions for the asset or value chain. As an example, the main sources of methane emissions found in onshore, dispersed oil and gas operations are typically different from those sources found in offshore operations. Care should therefore be taken when drawing global, industry-level conclusions about data, mitigation potential and costs based on information from a specific region or type of activity.

# Methane sources

*This section details some of the main sources of methane emissions, providing context around what they are, where they are found and why they occur. This list is not exhaustive. As stated previously, it is important to note that the type of gas operation, e.g. onshore dispersed versus offshore, is often directly linked to the prevalence and significance of certain methane sources.*

*The elimination of a methane source is the preferred solution where technical and economically feasible. However, routing the gas to a flare system is also an acknowledged mitigation practice as the methane, which is a primary component of natural gas, is combusted to carbon dioxide which is understood to have a lower global warming potential.*

## BLOW-DOWN/DEPRESSURIZING

The depressurization and purging of piping, pipelines, compressors, vessels and other equipment under controlled conditions prior to maintenance and, potentially, when the equipment is taken offline. Piping, compressors, vessels and other equipment may also depressurize when operational upsets or abnormal conditions occur.

Natural gas from depressurization activities may be recovered as fuel, or routed to a flare system or an atmospheric vent.

## CASINGHEAD GAS

In the context of methane emissions, this is gas which builds up in the tubing/casing annular space in marginal 'stripper' oil wells with a low gas-to-oil ratio (GOR). Methane emissions occur when this gas is vented to reduce annular pressure and enhance flow from the reservoir into the wellbore, thereby increasing oil production.

*Additional information*

*The GOR indicates gas volume in relation to the oil extracted under standard conditions. It can be reported, for example, in units of standard cubic feet per barrel.*

## COMPRESSOR

Equipment which can be responsible for several potential equipment-specific sources of methane emissions that vary according to the type and design of the compressor and compressor seals. Each unique compressor-related source is defined and discussed separately in the following text.

These unique sources are:

- centrifugal compressor dry seal buffer gas vent/leakage;
- centrifugal compressor wet seal degassing tank vent;
- reciprocating compressor rod-packing leakage; and
- blow-down vent valve or isolation vent valve leak-through/leakage.

*Additional information*

*It is relevant to note that, in addition to the compressor-specific sources described in more detail below, compressors also have components that are typically associated with other types of equipment and emission source categories, e.g. valves and pneumatic controllers.*

- **Centrifugal compressor dry (gas) seals:** mechanical face seals, consisting of a mating (rotating) ring and a primary (stationary) ring. During operation, grooves in the mating ring generate a fluid-dynamic force causing the primary ring to separate from the mating ring, creating a 'running gap' between the two rings.

  Inboard of the dry gas seal is the inner labyrinth seal, which separates the process gas from the gas seal. A sealing gas is injected between the inner labyrinth seal and the gas seal, providing the working medium for the running gap and the seal between the atmosphere or flare system and the compressor internal process gas. Outboard of the dry gas seal is a barrier seal, which separates the gas seal from the compressor shaft bearings. A separation gas (typically nitrogen or air) is injected into the barrier seals.

  Typical dry gas seal assemblies are 'tandem' seals which consist of a primary seal and a secondary seal contained within a single cartridge. During normal operation, the primary seal absorbs the total pressure drop to the user's vent system, and the secondary seal serves as a backup should the primary seal fail (Stahley, 2002).

*Additional information*

*Emissions from a dry seal are of the seal gas itself, typically a cleaned and conditioned natural gas, rather than the process gas internal to the compressor. The seal gas flow rate into the seal assembly is controlled to maintain adequate flow velocity across the inner labyrinth seal to prevent process gas from the compressor flowing into the seal assembly. Most of the seal gas flows into the compressor case across the labyrinth seal, with a small portion flowing between the mating and primary rings where it is vented from the seal assembly primary seal vent and may be routed to an atmospheric vent or flare system.*

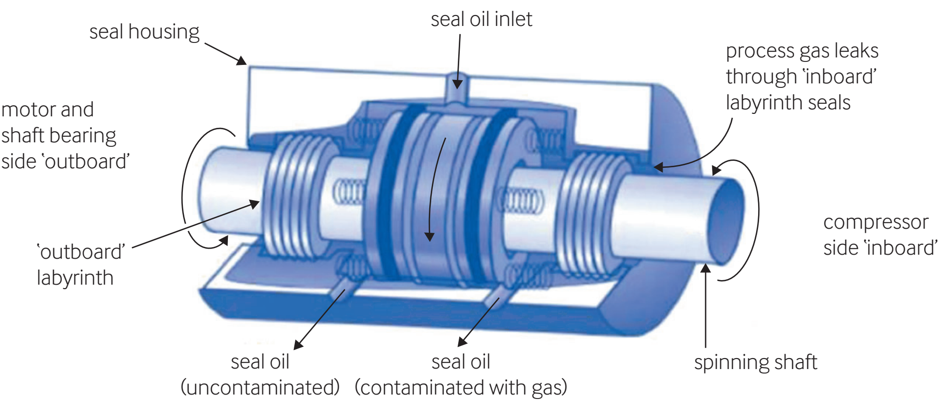
*Some seal gas will flow between the secondary seal mating and primary rings, and exit the seal assembly from the secondary seal vent which may be routed to an atmospheric vent or flare system. A typical centrifugal compressor will have two seal assemblies—one at each end of the compressor shaft.*

- **Centrifugal compressor wet seals:** a seal system that uses special seal-oil, which is circulated internally to the seal assembly under higher pressure than the gas in the adjacent compressor case, and which serves as the sealing fluid/mechanism. Wet seals can be mechanical seals, with the seal oil providing liquid film sealing, lubrication and cooling.

Seal oil acts as a liquid film and barrier fluid, for example between the rings around the compressor shaft (similar to a dry gas seal). Wet seals have an inboard labyrinth seal that keeps higher-pressure seal oil from flowing into the compressor case. The inboard seal oil comes into contact with the process gas and is contaminated with entrained and absorbed gas (this contaminated seal oil is often called 'sour seal oil'). The outboard seal oil does not come into contact with the process gas and, hence, is not contaminated. Inboard contaminated seal oil is routed to an atmospheric pressure degassing tank where the entrained and absorbed gas is removed prior to recirculation.

Example of a typical centrifugal compressor with wet seal assemblies

(Source: US EPA (2006)



Very little gas escapes through the oil seal barrier and emissions are typically from the degassing tank vent, in those cases where the entrained and absorbed gas is vented (as opposed to recycled or flared). Many seal-oil systems have a 'sour seal-oil trap' (essentially a small separator) where the majority of the entrained and absorbed gas is removed from the seal oil at higher pressure and routed to a recovery or flare system before it reaches the seal oil degassing tank (newer systems use dry seals).

*Additional information*
*A typical centrifugal compressor will have two seal assemblies, one at each end of the compressor shaft, and one seal-oil degassing tank serving both seal assemblies.*

- **Reciprocating compressor rod packing:** consists of a series of mechanical rings, contained in a packing case, that provide a seal against the piston rod to restrict the leakage of compressed gas from the compressor cylinder along the compressor rod. Rod packing designs and materials vary according to operating and process conditions. Different compressor duties require different packing ring designs and material selection. The gas properties, pressure differentials, compressor speed and type of service are all used to determine the proper combination of ring style and material that will provide the optimum pressure seal and oil wiping.

  *Additional information*
  *A reciprocating compressor will have a rod packing assembly on each cylinder or 'throw'. For example, a compressor with four cylinders will have four rod packing assemblies.*
  *Pressure packing assemblies typically have a packing case vent designed to enable gas that has leaked past the sealing rings to be vented to a safe location. These packing case vents can be routed either to an atmospheric vent or flare system. Any gas leakage not vented from the packing case vent may leak into the compressor distance piece which operates at atmospheric pressure, and is typically vented to the atmosphere.*

- **Compressor blow-down valves:** valves which are opened when a compressor is in a depressurized mode. In normal operation, these valves isolate the pressurized compressor from the blow-down vent stack or line routed to the flare header. Leakage through the valve trim can often occur, which results in gas being vented from the compressor blow-down vent stack or flowing into the flare header. This source is not specific to the type of compressor and can occur with centrifugal, reciprocating and other types of compressors.

- **Compressor isolation valves:** the suction and discharge valves that are closed when a compressor is in a shutdown and depressurized mode, and which isolate the compressor from gas/pressure in the suction and discharge piping/headers. Similar to the blow-down vent isolation valve, these valves may leak through, with the gas then vented from the blow-down stack or flowing into the flare header depending on the routing of the blow-down line. This source is not specific to the type of compressor and can occur with centrifugal, reciprocating and other types of compressors.

## COMBUSTION

The combustion of gas in fuel-burning equipment is not 100% efficient, and some methane emissions occur as a result of uncombusted gas being released via the equipment exhaust stream. The uncombusted proportion of gas varies between internal and external combustion sources (engines, turbines and heaters/boilers) and, therefore, equipment-specific data or emission factors are typically used for emissions quantification.

## FLARING

The controlled burning of gas, including associated gas, in the course of oil and gas operations. In many types of operations, including those where gas is sold, reinjected or otherwise utilized, safety flaring represents an important and necessary activity to ensure safe operations. The combustion efficiency of a well-designed and operated flare is generally assumed to be greater than 98%, meaning that less than 2% of the gas passes through the flare stack unburnt. At the individual flare level, consideration of the local parameters such as gas content and quality, flare design, flow rates, exit velocities and steam use will all contribute to the overall combustion efficiency. There are currently no straightforward methods to continuously measure or monitor the actual combustion efficiency or destruction and removal efficiency of a flare.

## FUGITIVES

Unintentional emissions of gas from equipment and processes. Typical equipment components where fugitive emissions can occur are valves, screwed connections, flanges, open-ended lines and pump seals.[1]

[1] Other organizations and stakeholders have different definitions or criteria for what constitutes fugitive emissions that fall on the spectrum between this definition and the IPCC broad definition (which includes almost all greenhouse gas (GHG) emissions except those from fuel combustion).

## GLYCOL DEHYDRATOR

Process unit that removes water from gas by contacting high pressure wet gas with glycol, which absorbs the water from the gas. Emissions from a glycol dehydration unit are highly dependent on how the unit is configured and operated. The two potential emission points from a glycol dehydrator are the flash tank overhead gas (if equipped with a flash tank) and the regenerator distillation still vent off-gas. Estimating air emissions from glycol units using triethylene glycol (TEG), diethylene glycol (DEG) or ethylene glycol (EG) can be performed by using a Windows®-based program such as GRI-GLYCalc™.

*Additional information*

*Additional information on operation and methane mitigation methods can be found in the US EPA Natural Gas Star Program (https://www.epa.gov/natural-gas-star-program).*

## HYDRAULIC FRACTURING/'FRACKING'

Part of the completion process by which fluids are injected at high pressure down a wellbore and through perforated casing. Fractures are created in the targeted hydrocarbon bearing strata, creating pathways for hydrocarbons and water to flow into the wellbore. Specifically, the process includes directing pressurized fluids containing a combination of water, chemicals and proppant (sized particles mixed with fracturing fluid to hold fractures open after a hydraulic fracturing treatment), to stimulate tight formations, such as shale formations, to release hydrocarbons. Natural gas may be returned with water and hydrocarbon liquids from the wellbore during the flowback phase as well as during production. The flowback process has the potential to result in the venting of significant volumes of gas to the atmosphere unless equipment is in place to separate the gas from the liquids and solids that are also returned, and allow the gas to be captured.

## HYDRAULIC FRACTURING— REDUCED EMISSION COMPLETION/ GREEN COMPLETION

The process by which natural gas is recovered during the flowback phase and either sold or used for beneficial purposes. Hydraulic fracturing is considered a 'reduced emission completion' (REC) or 'green completion' when flowback emissions from the gas outlet of the separator are vented, captured, cleaned and routed to the flow line or collection system, re-injected into the well (or into another well), used as an on-site fuel source, or used for some other useful purpose that a purchased fuel or raw material would serve, with *de minimis* direct venting to the atmosphere. Short periods of flaring during a reduced emission completion may occur.

## LIQUIDS UNLOADING

A generic term describing a variety of technologies and techniques for managing and preventing the buildup of a wellbore liquid column, particularly in low production-rate gas wells. It is also known as wellbore deliquification. As the production rate in a gas well declines with age, the velocity of the gas flow up the tubing may fall below the critical velocity necessary to 'drag' liquid droplets up through the wellbore. When this occurs, a liquid column will build up in the tubing, which puts hydraulic back pressure on the reservoir and further reduces the gas inflow rate. A variety of different techniques and technologies are used to manage this buildup of wellbore liquid, and to prevent production from slowing or ceasing. These techniques and technologies can be grouped into two categories—those that depend on the reservoir energy, and those that add energy to the wellbore. Those dependent on reservoir energy include intermitting (shutting in a well for buildup which increases the flow rate when restarted), installing plunger lift systems along with appropriate control systems, and installing velocity tubing (smaller diameter) in the wellbore. Technologies that add energy include pumps of various types and gas lift systems.

*Additional information*

*Emissions associated with deliquification occur when wells using techniques dependent on reservoir energy are vented to the atmosphere to increase the pressure differential between the bottom of the well and the surface. The number of atmospheric venting cycles, and hence the volume of emissions, is highly dependent on the approach taken to manage the reservoir energy to achieve the necessary flow rate or pressure differential. The importance of the type of approach taken can be demonstrated by looking at US data collected in the US EPA's Greenhouse Gas Reporting Program. These data show a highly skewed distribution, with ~4% of company/basin reports accounting for more than 75% of reported emissions.*

*Once a technique which adds energy (pump or gas lift) is implemented, venting will not typically occur.*

## PLUNGER LIFT

A system installed on a well to assist in deliquification when there is no longer consistent and sufficient flow velocity to produce the well. A plunger lift system uses the well's own energy (gas/pressure) to lift liquids from the tubing by pushing the liquids to the surface; this is achieved through the movement of a free-travelling plunger ascending from the bottom of the well to the surface.

When directed by the plunger control system, the plunger drops from the well lubricator and falls to the bumper spring and landing tool that is typically located at the production zone. As pressure increases in the well, typically after well shut-in, the plunger acts like a pipeline pig and begins lifting the liquids to the surface. Flow can be directed to the separation equipment and sales line, in which case emissions do not occur. Flow can also be directed to storage tanks, with the gas vented to the atmosphere, or to separation equipment with gas vented to the atmosphere.

## PNEUMATIC GAS EMISSION SOURCES

Sources of emissions where natural gas pressure is used as an energy source to operate various instrumentation and equipment, ultimately resulting in emissions of the actuation gas. This type of instrumentation and equipment is normally used in places where electrical power or instrument air are not available.

Typical pneumatic gas uses and emission sources are:

- pneumatic controllers and their associated valve actuators/positioners or end devices such as louvre positioners or plunger-pin actuators;
- pneumatic pumps; and
- miscellaneous pneumatic equipment such as engine/turbine starter motors.

Each of these uses and emission sources are discussed in more detail below.

- **Pneumatic controller:**
  an instrument that takes a mechanical, electrical or pressure input signal proportional to a process variable or position being controlled, and which controls the flow of pneumatic power gas to and from an end device (most often a control valve actuator) to change the state or magnitude of the process variable being controlled. A complete control loop includes: a sensing device which senses the state of a process variable such as pressure, temperature, differential pressure (surrogate for flow), level or position; the pneumatic supply gas; the controller; the end device, such as a valve actuator; and miscellaneous tubing.

  *Additional information*
  *From an emissions perspective, pneumatic controllers can be classified into the following distinct categories:*

  - ***Continuous bleed controllers** emit gas continuously, with the rate dependent on the critical orifice diameter, supply gas gravity and supply gas pressure. In the US, continuous bleed controllers have been subdivided into low bleed (<6 scf/hr) and high bleed (>6scf/hr) devices.*

- *Intermittent vent controllers vent gas to the atmosphere to reverse an actuation action taken. Most often this involves venting all or part of the volume of a valve actuator and supply tubing to partially or fully reverse the actuation action. Intermittent controllers, if working correctly, have much lower emissions than continuous bleed controllers. The vented gas rate (scf/hr) is dependent on the supply gas gravity, supply gas pressure, tubing and actuator bonnet volume, and the number of actuations per hour.*
- *Safety/shutdown devices/controllers typically hold a fail-close valve open and, if functioning properly, release emissions only in abnormal operation scenarios.*
- *Zero emission controllers are integrated controller, actuator and control valve devices that discharge the pneumatic control gas into the lower pressure downstream of the controller rather than to the atmosphere, and do not emit natural gas. These types of devices use gas from the system upstream of the device. Examples are back pressure control and pressure regulator type devices where the downstream system pressure is less than the upstream pressure.*
- *Hybrid controllers combine features of intermittent vent and continuous bleed design or other novel designs.*

*These are not common types of devices, and most controllers can be classified into one of the four categories above.*

- **Pneumatic controllers—bleed vs vent:**

  **Bleed:** a pneumatic process where the control media is intentionally bypassed from source pressure to the atmosphere through a bleed port, to provide a constant downstream reference pressure for control purposes.

  **Vent:** the release of pneumatic control gas, while the supply gas is isolated from the actuation space.

- **Pneumatic actuator:**

  a pneumatic device that creates linear or rotary motion to move or actuate an end device (typically a control valve) by converting pneumatic gas pressure to motion. Pneumatic actuators enable large forces to be produced from relatively small pressure changes acting on the cross-sectional area of the diaphragm or plunger.

- **Pneumatic control loop instrumentation and end device:** a device that uses pneumatic gas pressure (typically air, nitrogen, or natural gas) as the energy source for control. Pneumatic instrumentation using natural gas is most likely to be employed where there is no electricity for an instrument air system, and/or where there is insufficient pneumatic demand to justify an instrument air system.

- **Pneumatic pump:** a device that uses natural gas pressure as the energy source required to pump fluids. Two common types of pneumatic pumps are used in the oil and gas sector, generally when other sources of on-site power are not available. These are:
  - high discharge-pressure piston pumps, used for pumping relatively low rates of chemicals or methanol into high-pressure equipment/wells on a more or less continuous basis; and
  - low discharge-pressure diaphragm pumps, used for pumping higher rates of fluids for transfer (intermittent use) or speciality uses such as in hot glycol heat trace systems used at remote wells in cold environments (seasonal use).

  *Additional information*

  *Emissions from a pneumatic pump are dependent on the volume of fluid pumped, the discharge pressure of the pump, and the design of the pump. The manufacturer's pump curve or pump modelling program should be used to determine emissions for a particular model of pump in a particular service/use.*

- **Miscellaneous pneumatic equipment/pneumatic gas-powered equipment:** may be used for other miscellaneous services such as engine or turbine starter motors.

  *Additional information*

  *The use of pneumatic gas-powered equipment for miscellaneous uses such as engine/turbine starter motors is becoming less common.*

## SEAL BUFFER GAS

A gaseous compound (inert or volatile) that is injected into the seal assembly in a compressor to prevent process gas from entering the seal assembly and to provide a 'seal fluid' for some seal designs.

(See also 'Centrifugal compressor dry (gas) seals' on page 6.)

## STORAGE TANK

In the context of methane emissions and emissions management, any vessel that stores produced hydrocarbon liquids or produced water and operates at or near ambient atmospheric pressure. The hydrocarbon liquids or produced water may have been stabilized or be unstabilized. Methane emissions occur when the pressure of the liquids decreases and the entrained gas 'flashes' out of solution, resulting in the gas being vented.

Tank venting equipment is designed in accordance with engineering standards for both normal and emergency venting. Storage tanks downstream of the point where initial equilibration to atmospheric pressure occurs do not have the potential for substantial methane emissions. Other emissions can occur when the fluid is being pumped into, or out of, the tank and the movement of the fluid creates airborne vapour (working losses) that is either released or captured, or when vapour generated within the tank as a result of temperature or pressure variations escapes the system (breathing losses).

*Additional information*

*The amount of gas a hydrocarbon or produced water liquid will hold in solution is proportional to the pressure. The higher the pressure, the higher the quantity of solution gas, and the higher the potential flash emissions. Separating gas at the lowest pressure feasible minimizes the potential for methane flash emissions and may negate the need for post-flash controls such as vapour recovery units (VRUs) or routing to 'low low pressure' (LLP) flare systems to control methane emissions.*

## TANK BLANKET GAS

A gaseous compound flowed into a fixed roof tank at low pressure. This is a common practice for minimizing the amount of air entering a tank and creating an explosive atmosphere. Natural gas is sometimes used for tank blanketing, but other gases, such as inert gases, could be used instead.

## WELL COMPLETION AND FLOWBACK

Completion: a process undertaken to complete a well after it has been drilled, and prepare it for production. The subsurface well casing is perforated, often hydraulically fractured, and tubing and downhole well flow equipment is installed in the wellbore. The process is a precursor to, and allows for, the flowback of petroleum or natural gas from newly drilled or recompleted wells, to expel drilling and reservoir fluids and test the reservoir flow characteristics.

**Flowback:** a process that occurs after a well is completed or recompleted, whereby fluids and entrained solids are allowed to flow from a natural gas or oil well following a treatment, either in preparation for a subsequent phase of treatment or in preparation for clean-up and returning the well to production. The term 'flowback' also refers to the fluids and entrained solids that emerge from a natural gas well during the flowback process.

The flowback period begins when material introduced into the well during a treatment returns to the surface following hydraulic fracturing or refracturing. The flowback period ends when either the well is shut in and permanently disconnected from the flowback equipment or at the start-up of production. The flowback period includes the initial flowback stage and the separation flowback stage.

(See also 'Hydraulic fracturing—reduced emission completion/green completion' on page 10.)

*Additional information*

*Flowback also occurs after drilling and/or well work that does not include hydraulic fracturing. It is also mostly relevant to the US onshore type of development.*

# Emission estimation methodologies

*This section documents some of the main methodologies and related terms used in relation to estimating methane emissions.*

## BOTTOM-UP EMISSION ESTIMATE

Method of using 'ground-based' techniques to directly measure or estimate emissions at the facility level (e.g. well pad, compressor station) or the emissions source/activity level (e.g. compressor engine exhaust, storage tanks, equipment leaks).

(See also 'Top-down emission estimate' on page 19.)

## BOTTOM-UP EMISSION INVENTORY

Inventory based on direct measurements, engineering calculations, manufacturer data and emissions factors for emissions sources/activities, compiled to develop an account of emissions discharged to the atmosphere from a facility (e.g. compressor station) or a geographic area (e.g. basin, state, region).

## DETECTION THRESHOLD

The minimum quantity or concentration of a gas (e.g. methane) which is detectable by detection equipment.

## EMISSION FACTOR

Factor relating activity data (e.g. tonnes of fuel consumed, tonnes of product produced, number of pneumatic controllers) to emissions. Emission factors generally take the form of the amount of emissions per activity unit, for example standard cubic feet of gas per hour (scf/hr) per pneumatic controller. Emission factors are typically developed based on a population of direct measurements of emission sources/activities.

## GLOBAL TEMPERATURE CHANGE POTENTIAL (GTP)

The ratio between the global mean surface temperature change at a given time horizon that is understood to follow an emission of an amount of gas relative to the same amount of carbon dioxide ($CO_2$).

## GLOBAL WARMING POTENTIAL (GWP)

A factor which estimates the contribution to global warming of a given mass of a greenhouse gas species, relative to the same mass of $CO_2$ over a particular time frame. The time period for any quoted GWP is important as there are significant differences between 1-year, 20-year and 100-year GWPs; for example, the GWP for methane is understood to range from 25 to 84 depending on the timeline adopted. The time period usually used for GHG inventory reporting is 100 years. The IPCC Assessment Reports provide relevant GWPs for methane and other GHGs.

## SHORT-LIVED CLIMATE FORCERS (SLCFS)

Atmospheric compounds, including methane, hydrofluorocarbons and black carbon, that are understood to have an important but relatively short-lived effect on global temperature. It is thought that in insolation, early action on SLCFs could affect the projections for temperatures and other climate impacts that would be observed by today's generation of decision makers, but would have little impact on the warming that may be experienced by future generations. Unless it is accompanied by ambitious reductions in $CO_2$ emissions, it is understood that early SLCF mitigation would also have little impact on eventual peak warming.

## SUPER-EMITTER

A term used to describe the concept that certain methane sources can represent a disproportionate amount of the total methane emissions released from all sources. The term 'super-emitter' can refer to malfunctioning equipment, particularly in unmanned installations where such equipment has the potential to exist for long periods of time. The determination of a super-emitter is best associated with emissions data from a given source and should not be viewed as an attribute of an entire site. Care should be taken when utilizing methodologies for identifying super-emitters to differentiate between episodic events (e.g. gas actuation events), erroneous measurements and/or malfunctioning equipment. The term 'fat-tail' is often used to describe the statistical representation of the data—a probability distribution that is highly skewed relative to a well-behaved distribution such as the normal or an exponential distribution. Having super-emitters at a few sites could skew significantly the distribution of emissions from a sample of sites.

## TOP-DOWN EMISSION ESTIMATE

Estimate made using different 'aerial-based' techniques to measure ambient air concentrations of methane, calculate methane flux based on atmospheric and meteorological conditions, and then attribute the emission portion due to different activities. Each measurement technique has different resolution capabilities, strengths and weaknesses.

Methane emissions are allocated to the natural gas industry by: (a) using a ratio of methane to ethane or propane (longer chain aliphatics which do not occur from biogenic sources); (b) isotopic ratio analysis, using a co-located tracer (such as $SF_6$ or $C_2H_2$); or (c) subtracting estimates of other sources of methane emissions such as, livestock, wetlands, agriculture, waste management, etc. together with background methane concentrations.

(See also 'Bottom-up emission estimate' on page 17.)

# Methane detection and measurement technologies and work practices

*This section lists some, but not all, technologies and work practices that can be used to both quantitatively and qualitatively measure methane emissions.*

## ACOUSTIC DETECTION DEVICE

A device used to detect the acoustic signal that results when pressurized gas leaks through a valve or other small diameter opening. The acoustic signal is detected by the analyser, which provides an intensity reading on the meter. Acoustic detectors do not measure leak rates, but can provide an indication of leakage rate based on empirical derived correlations.

## CALIBRATED ANTI-STATIC VENT BAG

An anti-static bag calibrated to a specific volume and used to estimate the flow rate. It is used to enclose an emission source to completely capture the leaking gas. The time required to fill the bag with emissions is measured using a stop watch. The volume of the bag and time required to fill it is used to determine the rate of emissions.

*Additional information*

*Different equipment leak detection instruments have different levels and types of detection capabilities, i.e. some instruments provide a visual image while others provide a digital value on a scale (not necessarily directly related to mass emissions). Hence the magnitude of actual emissions can only be determined after measurement.*

## DIRECTED INSPECTION AND MAINTENANCE (DI&M)

A programme designed to provide a cost-effective way to proactively detect, measure, prioritize and repair equipment leaks. Based on initial surveys, directed maintenance practices may be implemented to inspect and repair equipment before leaks occur. Leak survey frequencies may also be established for areas, facilities and even specific equipment based on observed leak frequencies and/or leak size.

(See ‘Leak detection and repair (LDAR)’ on page 21.)

## EQUIPMENT LEAK DETECTION

The process of identifying emissions from equipment, components and other points by screening for, and detecting, fugitive emissions. A screening device may be used to screen a wide area to detect the presence of fugitive methane or vented methane, and a detection device can be used to identify a specific fugitive or vented source of leak. Note that most detection and screening instruments and devices (particularly handheld devices) do not quantify the volume or mass of the emissions.

## HIGH VOLUME SAMPLER

A device used to measure the concentration of emissions from a source.

## INFRARED (IR) CAMERA

Refers to a device (camera) equipped with infrared sensors for detecting gases that have infrared absorption bands within the band-pass filter installed in the device. Includes Optical Gas Imaging (OGI) and forward-looking IR cameras. The camera can 'see' hydrocarbon-based equipment leaks as well as other compounds, e.g. steam. IR cameras detect leaks but do not quantify them.

*Additional information*

*Compared to handheld technologies that employ a 'sniffing' technique to detect each possible leak component, IR cameras are easier to use, very efficient (they can detect multiple leaks at the same time) and can be used to perform a comprehensive survey of a facility. The main disadvantage of an IR camera is that it may involve substantial upfront capital investment depending on the features that are made available. It should also be noted that operators should be trained in the use of the camera and inspection procedures to ensure that meaningful results are obtained.*

## LEAK DETECTION AND REPAIR (LDAR)

A programme to identify and repair the equipment or infrastructure that can be a source of methane leaks. While LDAR in certain jurisdictions can have a specific regulatory definition it is more generally used to describe the processes and systems by which leaking equipment is identified, prioritized and then repaired. Within the LDAR programme, a variety of techniques can be employed such as the use of optical gas imaging cameras.

(See 'Directed Inspection and Maintenance (DI&M)' on page 20.)

## METHANE DETECTION

Can be defined as the process of identification of methane emissions from potential sources, without the measurement of the mass quantity (flow rate, e.g. kg/hr). Several devices, screening instruments and methodologies are available to detect methane emissions, including optical gas imaging cameras, laser leak detectors, portable analysers (OVAs, TVAs), soap bubble screening and/or AVO methods. Some of these are able to detect and provide a concentration level (volume, e.g. ppmv) that can be used to estimate the mass emission (e.g. by applying specific emission factors or correlation equations available from literature).

## METHANE EMISSIONS

A broad term to cover all releases of methane including planned (e.g. process equipment) and unplanned (fugitive) sources.

## METHANE FLUX

The rate of mass flow of methane through a unit area perpendicular to the wind flow direction. Units of measure are expressed in g $CH_4/m_2/yr$. Flux can be calculated using methane concentration and wind speed, and estimated across the entire cross-sectional area of one square metre.

The calculation therefore assumes a homogeneous flux perpendicular to the one square-meter window. Uncertainties include a potentially different wind speed at the height of where the wind is measured compared to the methane sensor's height.

## METHANE INTENSITY

The ratio of methane emissions (numerator) over a selected variable (denominator). It can be determined for a facility (e.g. compressor station), an area (e.g. production basin) or even an entire value chain (e.g. natural gas production through to distribution). A methane intensity prevalently used is total methane emissions in gigagrams emitted from a facility, area or value chain (numerator) divided by well production volume, facility throughput or area production volume in gigagrams (denominator) and reflected as a percentage.

## METHANE LEAK

The unplanned release of methane from plant, production operations, systems and processes, typically from flanges, joints and connections. Often referred to as fugitives.

(See 'Fugitives' on page 9.)

## METHANE MEASUREMENT

The process of taking a reading of the methane concentration or methane emission rate within an air sample at a specific point in time. Typical units for a measurement would be parts per million (ppm), parts per billion (ppb) or kilograms per hour. Note that it is important to understand global and local background methane concentrations to contextualize the data. Emissions measurements may be performed as one-time activities, at regular intervals or on a continuous basis, but it is important that the measurements are representative. A variety of techniques are described in this section of the document.

## METHANE QUANTIFICATION

Includes methods for determining the size of a methane emission source in terms of customary units of emissions rate, such as mass per time (e.g. kilograms per hour) or volume per time (e.g. standard cubic metres per hour). This can be accomplished by engineering estimations, direct measurement of the methane source (such as bagging procedures, US EPA Method 21—see definition on page 24), and from models that use ambient measurements and meteorological data to infer an emission rate ('top-down' or 'bottom-up' approaches—see definitions on pages 19 and 17, respectively).

## SOAP BUBBLE TEST

Test conducted to determine the location of pressurized outgassing of fugitive emissions or venting, by applying a soap-water liquid solution over the surface of the suspected area. The soap bubble test represents an alternative to other forms of leak detection. Gas emissions can be confirmed by the presence of bubbles and the growth in size of those bubbles. This leak detection method is best performed with surface temperatures below that of evaporation, and with continuous visual observation of the soap bubble growth.

## TUNABLE DIODE LASER ABSORPTION SPECTROSCOPY (TDLAS)

An optical method for detecting trace concentrations of one or more selected gases mixed with other gases. This gas detection technology has many unique advantages, such as intrinsic safety, good stability, good selectivity and long working life.

*Additional information*

*TDLAS sensors are gaining acceptance for natural gas and methane leak surveying and other standoff detection applications. Handheld, and vehicle- and aircraft-mounted versions are currently in use.*

## US EPA METHOD 21

US EPA Technical Guidance on 'Determination of Volatile Organic Compound Leaks'. This method is applicable for the determination of VOC leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals and access door seals.

# General terms

## UPSTREAM, MIDSTREAM AND DOWNSTREAM

The oil and gas value chain is typically divided into three sectors, typically referred to as upstream, midstream and downstream, though other divisions and terms may also be used. Because these terms are used so broadly, the activities and operations included in the concept of one sector may vary depending upon how the term is used and by whom. It is therefore difficult to set definitive boundaries between each sector. Differing use of these, and other, sector terms, e.g. in publications and public reports, may lead to confusion. The descriptions of these terms below are therefore intended only to provide general guidance.

- Upstream: activities and/or operations involving the exploration, development, and production of oil and gas.
- Midstream: the sector of the oil and gas value chain that includes the transportation of crude oil to petroleum refineries and natural gas to processing facilities, and the further distribution of natural gas to local distribution companies. It may include oil processing or natural gas processing plants, either for upgrading the product to market specifications, for example through the removal of sulphur contaminants, or for separation into gas and natural gas liquids (NGLs).
- Downstream: considered to be the last sector in the hydrocarbon value chain over which the oil and gas industry has influence. This sector includes the refining, marketing and distribution of oil and gas products to end users. Some organizations and standards may include other stages of the value chain within their definition of downstream, depending on the boundaries that they have used to differentiate each sector. In general, however, 'downstream' encompasses the last stages of the life cycle of a product.

When using the sector definitions stated above, care should be taken with regard to terminology used by others.

# Acronyms

| | |
|---|---|
| AVO | Audio/visual/olfactory |
| $C_2H_2$ | Ethyne (acetylene) |
| $CO_2$ | Carbon dioxide |
| $CH_4$ | Methane |
| DEG | Diethylene glycol |
| DI&M | Directed Inspection and Maintenance |
| EG | Ethylene glycol |
| GHG | Greenhouse gas |
| GOR | Gas-to-oil ratio |
| GTP | Global temperature change potential |
| GWP | Global warming potential |
| IPCC | Intergovernmental Panel on Climate Change |
| IR | Infrared |
| LDAR | Leak detection and repair |
| LLP | Low low pressure |
| NGL | Natural gas liquid |
| OGCI | Oil and Gas Climate Initiative |
| OGI | Optical gas imaging |
| OVA | Organic vapour analyser |
| PPMV | Parts per million by volume |
| REC | Reduced emission completion |
| Scf/hr | Standard cubic feet per hour |
| $SF_6$ | Sulphur hexafluoride |
| SLCF | Short-lived climate forcers |
| SLCP | Short-lived climate pollutants |
| TDLAS | Tunable diode laser absorption spectroscopy |
| TEG | Triethylene glycol |
| TVA | Toxic vapour analyser |
| US EPA | United States Environmental Protection Agency |
| VOC | Volatile organic compounds |

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# IPIECA

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance, and is the industry's principal channel of communication with the United Nations.

Through its member-led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

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IPIECA also has an active global network of oil and gas industry association members. Please refer to the IPIECA website for a full list.


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