Brief description of source

After initial drilling, all wells must undergo well completion to flush out drilling fluids and cuttings before commencing production. Completion of new wells and reworking of existing wells in tight formations may involve hydraulic fracturing of the reservoir to increase well productivity. Hydraulic fracturing involves fracturing the reservoir rock with very high-pressure water containing a proppant (usually sand). This keeps the fractured surfaces 'propped open' after the water pressure has been reduced. At the end of the process, the excess water and proppant are removed. This well cleanup process may result in significant releases of methane into the atmosphere.

Completing hydraulically fractured wells involves producing the fluids at a high rate to lift the water and excess sand to the surface and clear the well bore and formation to initiate oil and gas flow. Typically, the gas-liquid separator installed for normal well flow is not designed for these high liquid flow rates and three-phase (gas, liquid, and sand) flow. Therefore, a common practice for this initial well completion has been to redirect the recovered fluids to a pit or tanks where water, hydrocarbon liquids, and sand are captured and slugs of gas vented to the atmosphere or flared. Completions can take anywhere from several hours for oil wells to several weeks for gas wells, during which time a substantial amount of gas may be released to the atmosphere or flared. Production levels are tested during the well completion process, and it may be necessary to repeat the fracture process to achieve desired production levels from a particular well.

A common practice in North America, required by US EPA regulations[1] for hydraulically fractured oil and gas wells is to route completion flowback to "reduced emissions completion" (REC) equipment. This equipment includes a purpose designed sand separator and over-sized gas/liquid separator which captures gas of a quality that can be sent to a sales pipeline. Initial flowback, especially where inert gases such as carbon dioxide or nitrogen are injected with the fracture water (energized frack) may be unsuitable for injecting into the sales line, and is normally tested and vented until it meets the desired pipeline quality.

System boundaries

Methane that is vented to atmosphere (continuously or periodically) from a pit or tank (where the recovered fluids and solids are temporarily stored), including initial flowback using REC, during completion of gas wells[2] following hydraulic fracturing are considered herein. Methane gas routed to sales, reinjected into the reservoir, or for on-site use, i.e. not vented, are not to be reported. Methane emissions captured and routed to flare or thermal oxidation should be reported under Flaring (see Flaring TGD).

Guidance on materiality is presented in the *General principles TGD.*

Level 3 Quantification Methodologies

[1] Oil and Gas New Source Performance Standards for Hydraulically fractured well completions: https://www.epa.gov/sites/default/files/2016-09/documents/sources_covered_2012nsps.pdf
[2] The qualification as gas well depends on the intended purpose of the well according to the location of the perforation

Emission Factors

Accepted source-level emission factors, as defined in the *General Principles TGD*, or those prescribed by local regulation are considered as providing Level 3 estimates, provided they are specific for the source type and based on throughput of product from the well. Partners are encouraged to use emission factors that best represent conditions and practices at their facilities and adjust the factors, where warranted, to more accurately estimate emissions given differences between the reference system on which the emission factor is based, and their systems.

The following tables present examples of emission factors which can be used to estimate methane emissions from gas well hydraulic fracturing.

Source	**Methane Emission Factor**[3]	
	(sm^3/completion)	**(scf/completion)**
Gas Well Completions with Hydraulic Fracturing: Uncontrolled Venting	52,175.97	1,842,577
Gas Well Completions with Hydraulic Fracturing: REC with Venting	24,534.08	866,413

NOTE: The emission factors presented were developed using data from hydraulically fractured oil and gas wells in the United States, where the use of RECs is well established and was developed based on data from onshore gas wells.

Level 4 Quantification Methodologies

There are no methods to quantify emissions from gas well hydraulic fracturing with flow routed to an open pit at Level 4. These emissions can neither be measured nor quantified using engineering calculations and are to be quantified at Level 3.

Direct measurement and Measurement-based Emission factor

Measurements (including continuous and periodic monitoring) or emission factors developed based on representative measured emissions are considered Level 4 emissions quantification. Measurements must be taken that represent the total flow and associated methane content of each gas stream that is vented to the atmosphere. Methane content can be determined based on accepted technologies and methodologies, as described in the *General Principles TGD*.

Accepted, equipment and techniques, as described in the *General Principles TGD,* for determining gas flow and composition are to be employed. If the produced gas is directed to a storage tank or a three-phase separator, Partners can measure the flowback rate at the vent stack of either unit using a recording flow meter. Recommended measurement tools include the following, but the list is not exhaustive[4]:

[3] API Compendium 2021, Table 6-5

[4] More details on various detection and measurement equipment can be found at CCAC, Conduction Emissions Surveys, Including Emission Detection and Quantification Equipment – Appendix A of the OGMP Technical Guidance Document, 2017

- Recording Turbine meter or ePV meter for flow rate
- Hotwire anemometer for flow rate
- Vane anemometer for flow rate
- Draeger Tubes for vent gas composition

Level 4 emissions quantification can also be based on measurements conducted on a representative sample from one or more hydraulic fractures in a common reservoir. System configurations, environmental and operating conditions (e.g. reservoir geology, oil or gas reservoir, pressure, horizontal or vertical drilling aspect, etc) should be considered in determining 'like' systems that carry common emission factors. Each system that is not 'like' will require determination of a separate value for that system, based on the appropriate measurement studies. For guidelines on the methodology to develop a statistically representative sample, please refer to the [*Uncertainty and reconciliation guidance].*

Engineering calculations

Since the flow rate is not consistent throughout the duration of the completion flowback, Partners can calculate the total flow volume from the recorded flowback rates and use the equation below to quantify emissions at level 4.

Some examples of such calculations can be found at:

- US EPA, Subpart W – Petroleum and Natural Gas Systems, Eq. W – 10A, Eq. W – 10B https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98/subpart-W

In the case where the flowback process is not continuous, Partners could add all the recorded flowback volumes to determine the overall flowback volume, deducting any amount of CO_2 or N_2 injected into the reservoir during the energized fracture job. This calculation methodology is shown in the following equation[5].

$$E_{s,n} = [FV_{s,p} - EnF_{s,p}]$$

$E_{s,n}$ = Annual volumetric total gas emissions in cubic feet at standard conditions from gas well venting during completions or workovers following hydraulic fracturing for a well.

$FV_{s,p}$ = Sum of all flow volumes measured from the well (cubic feet)

$EnF_{s,p}$ = Volume of N_2 injected gas in cubic feet at standard conditions that was injected into the reservoir during an energized fracture job for the well. If the fracture process did not inject gas into the reservoir or the injected gas is CO_2, then $EnF_{s,p}$ is 0.

[5] CCAC, Technical Guidance Document Number 8: Well venting/Flaring during well completion for hydraulically fractured gas wells, 2017