Upstream Methane Workshop Pre-Read

World Energy Outlook 2017: Special Focus on Natural Gas

The International Energy Agency's annual World Energy Outlook report provides strategic insight on what today's policy and investment decisions mean for long-term energy trends. The 2017 report includes a special focus on the role of natural gas, with a specific chapter on the environmental case for gas (chapter 10, see further reading). The key predictions for natural gas growth and the salient points in the environmental case for gas are summarised below

Global Natural Gas Market:

- Global natural gas use is expected to rise by 45% in the next 25 years, with 80% demand growth from developing countries.
- Gas faces a competitive future, competing with growth in renewables and less expensive coal. Gas demand growth is expected to remain around 1.6% per year over the next 25 years.
- There will be ample gas availability, with around half of global supply growth coming from unconventional gas, led by the US. LNG is also expected to grow significantly, increasing its share of long-distance trade to 39%.
- The US, Russia and Iran are, and will remain, the three largest gas producers, with China closing the gap with Iran by 2040.
- The EU will remain the largest gas importer, but the Asia Pacific region will account for 85% of growth in net imports.

The Environmental Case for Natural Gas

- "*As the cleanest burning fossil fuel which emits few local air pollutants, natural gas has many advantages in a world concerned about carbon emissions and air quality However,* ***methane emissions*** *along the natural gas value chain, if they are not abated,* ***threaten to reduce the climate benefits of using natural gas***."
- The IEA estimates that global oil and gas related methane emissions in 2015 were 76 MT, more than half of which stemmed from natural gas operations. This equates to a **methane intensity of approximately 1.7% across the value chain**. In contrast the IOGP reported a global average emission intensity for oil and gas production of **just under 0.1%, 80% less than the IEA estimate**.
- The uncertainty of oil and gas methane emissions levels is high, due a lack of accurate data and a reliance on mainly academic and NGO funded studies, which tend to extrapolate findings from a limited and potentially misleading dataset, mainly in the USA.
- The majority of methane emissions reported by companies are estimated using engineering calculations, which potentially over or, under-estimate actual methane emissions.
- The IEA estimates that it is **technically possible to reduce global methane emissions from oil and gas operations by roughly 75%,** and that emissions could be reduced by 40-50% just by implementing approaches that have no net costs, as the value of the captured methane is higher than the cost of the abatement measure.
- Worldwide action is needed to achieve two key goals: **measure and abate**. Measurement is critical to assess the efficacy of policy actions and to assure the public of effective implementation. Abatement is critical to reduce emission levels.

BP Context

- To meet the **rising demand for cleaner energy** we are aiming to increase the amount of gas in our portfolio from 50% to 60% by 2020.
- **BP methane emissions** for marketed sales gas from Upstream segment operations **in 2017 was 0.18%**[1]**.,** varying from <0.01% for Shah Deniz to 3% for Greater Plutonio [2]
- BP has stated externally that we are going to **lead on reducing methane emissions**[34], and as part of this, BP has signed up to a set of Guiding Principles (attached). The aim of the Upstream Methane Workshop is to develop a plan to enable Upstream to deliver its contribution towards meeting this aspiration and the Guiding Principles.

Methane Science

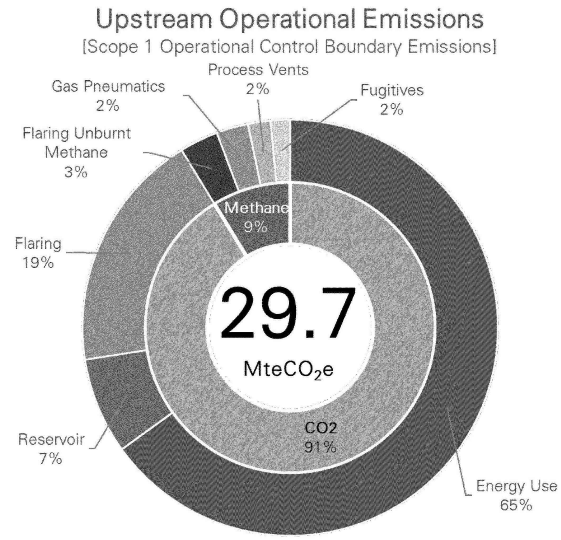
- **Methane is understood to have a stronger warming effect on the climate than CO_2**. But it breaks down relatively quickly in the atmosphere, with one of the resulting compounds being CO_2: So its assigned global warming potential (GWP) varies over time – the longer the timeframe, the more its GWP converges on that of CO_2:

[1] 0.18% in 2017 compared to 0.22% in 2016; reduction mainly due to methane emission reductions in L48 and increased gas export in Angola in 2017 compared to 2016.

3 https://www.bp.com/energytransition/shifting-towards-gas.html

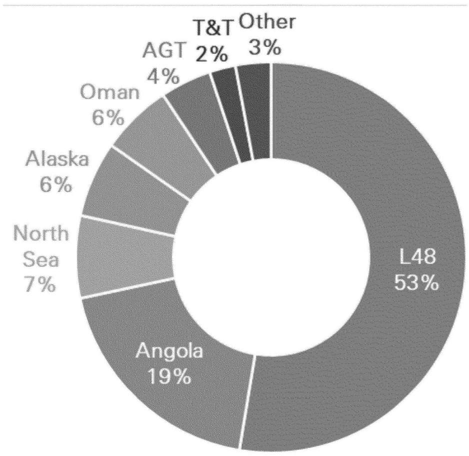
- Over 100 years methane has **25 times**[5] the GWP of CO_2.
- Over 20 years methane has **72 times**[3] the GWP of CO_2.

- BP uses the 100-year time frame for reporting, in line with most governments and companies, and the **IPIECA/API/IOGP Oil and gas industry guidance on voluntary sustainability reporting and UK Government Environmental Reporting Guidelines**.
- BP supports **Princeton University** research to better understand the methane cycle.

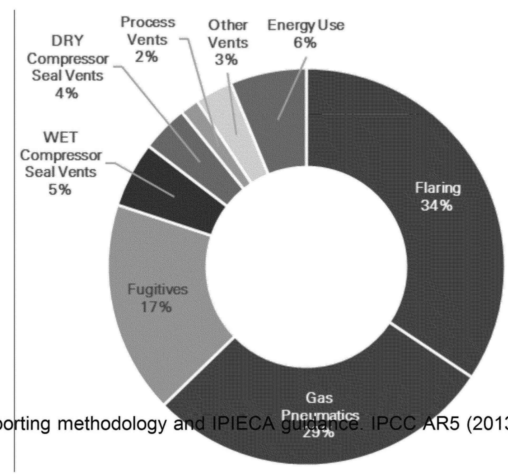


BP Upstream Methane Emissions

- When considering data on methane emissions, it is important to recognise that currently methane emissions are not routinely measured in the field. Instead, BP uses **regulatory required** (e.g. US EPA) or **standard industry** methods to calculate and estimate (e.g. using industry emission factors) our methane emissions. This is expected to change - several measurement technologies are being developed and trialled both within BP and through external initiatives.
- In 2017 Upstream will report emissions of **104,000 tonnes of methane** (100% of operated basis), down from 115,000t in 2016:
  - Using 100-year GWP this is equivalent to around **2.6 million tonnes of CO_2** (9% of Upstream total GHG emissions).
  - Using 20-year GWP this is equivalent to around **7.5 million tonnes of CO_2** (22% of the Upstream total GHG emissions).



- Over 70% of the Upstream methane emissions in 2017 (100% of operated basis) were from L48 and Angola:
  - **53% were from L48**, which has instrumentation and rotating machinery driven by natural gas at many small, dispersed and often remote sites, with associated methane venting and fugitive emissions.
  - **19% of methane emissions were in Angola**, related to flaring levels from its



[5] From IPCC Assessment Report 4 (AR4; 2007) and in line with current BP GHG reporting methodology and IPIECA guidance. IPCC AR5 (2013) values for methane GWP are 28 (100-year) and 84 (25-year).

[6] Angola FPSOs Greater Plutonio and PSVM currently account for just over half of Upstream's flaring

FPSOs[6] and reservoir gas issues associated with Angola LNG[7] unavailability. The region is investigating options for reducing flaring in 2018.

- Sources of Upstream operated methane emissions:
  - 34% from **flaring**, with over 50% from Angola.
  - 28% from **gas pneumatic controls and pumps** in L48, with ~70% of this from Wamsutter.
  - 17% from **fugitives**.
  - 9% from **compressor seals**, mainly wet seals at FPS (divested at end of 2017).
  - 5% from **venting**.
  - 6% during **combustion** of fuel gas.

Reporting Methane Emissions

- **Internal** – all BP operated and non-operated assets report GHG emissions (CO_2 and methane) annually; this data is used for internal performance analysis and external reporting. Since 3Q 2015, GOO has been reporting methane intensity internally based on total methane emissions from GOO operated assets over total operated oil and gas production and throughput. L48 report methane emissions through the annual GHG reporting cycle.
- **External** - to support our external advocacy position on gas we report total Upstream operated methane emissions over total operated sales gas[8]:
  - **Angola** methane intensity is high due to flaring, but lower than in 2016 (>5%) due to gas export to Angola LNG occurring throughout the year.
  - **L48** methane intensity is above BP's average (0.42% in 2017) due to the use of gas pneumatics.

Reducing Methane Emissions and Role of Technology

- **BP seeks to reduce methane emissions in our current operations, for example** through:
  - implementing leak detection and repair (LDAR) programmes;
  - quantification and minimisation of methane sources where technically and economically feasible, and
  - reducing flaring.
- L48 reduced their cumulative GHG emissions (primarily methane emissions) by over **2 MT CO_2e in the period 2000 to 2016 through:**
  - Converting high-bleed pneumatic controllers to low-bleed or intermittent
  - Reducing liquids unloading venting through enhanced automation, plunger lift, and shut in cycles
  - Converting pneumatic chemical injection pumps to solar pumps

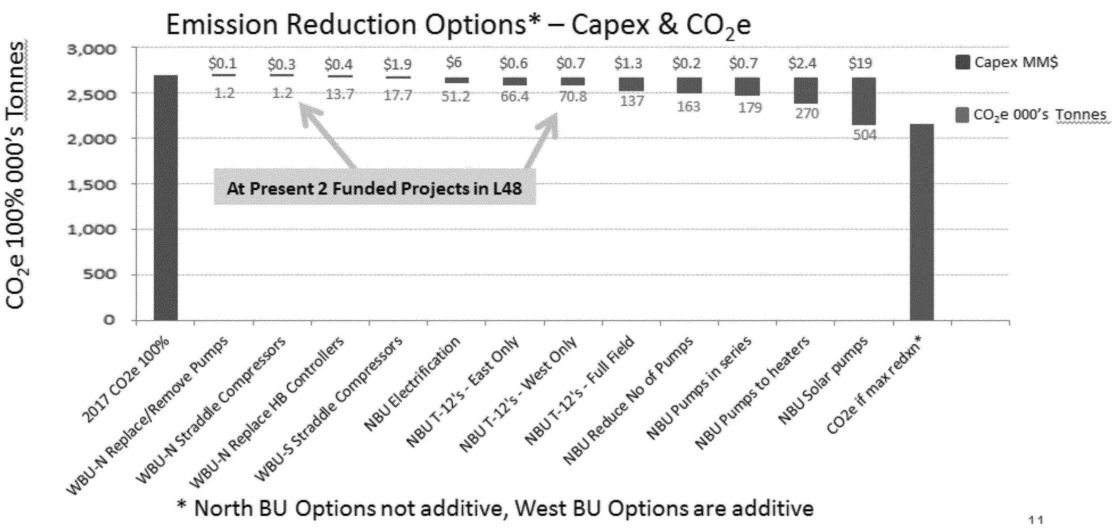
[6] Angola FPSOs Greater Plutonio and PSVM currently account for just over half of Upstream's flaring

[7] Angola LNG is the associated gas export route for the Angola offshore region; it is a 3rd party facility operated by Chevron

[8] This includes gas from production facilities and associated gas that reaches a sale or export point (e.g. Angola) and excludes gas that does not reach market (e.g. Prudhoe Bay)

- ➢ Implementing green completions to reduce venting and flaring during completions
- ➢ Optimizing compressor engine fleet reducing the number and size of compressor engines
- ➢ Installing waste heat recovery unit at Florida River Plant

- L48 continues to reduce emissions through, for example:
    - ➢ Conducting leak detection and repair at approximately 500 production locations.
    - ➢ Reducing the number and size of compressor engines fleet
- L48 has examined potential options to further improve performance, which are shown in the waterfall chart below. The North BU options show the CO2 equivalent tonnes of reduction possible for each option, whereas the West BU options show the additive CO_2 equivalent tonnes of the displayed options.



- **BP has added rigour to project design aimed at reducing methane emissions e.g. Khazzan.**
- **Technology** will play a key role both in improving the efficiency of our operations and identifying, quantifying and reducing sources of methane.
- We are **trialling and deploying technologies** within our own operations, and through joint industry projects with our peers, e.g. through the $1 billion over ten years OGCI Climate Investments and the Petroleum Environmental Research Forum (PERF).
- For example, we are evaluating and trialling technologies to enhance quantification of methane emissions and emission reductions:
    - ➢ **Measurement of flare combustion efficiency** (we currently have no means of measuring flare combustion efficiency at our operations).
    - ➢ **Fugitive emission rates quantification** technology and its potential for systematic use in our LDAR program across GOO.
    - ➢ **Installation of a Gas Cloud Imaging (GCI) camera at the Ghazeer Project in Oman, to enable continuous monitoring and generation of real-time data for the detection and quantification of gas leaks.**
    - ➢ L48 trials of **aerial leak detection using drones**.

Peer Activities and External Disclosure

- **The Upstream industry's methane performance has been incorrectly represented externally**, with onshore unconventional US intensities being extrapolated to represent the entire oil and gas industry global methane emissions.
- In response, **some of our industry peers have published data and targets related to methane intensity**, as well as joining a number of external initiatives focusing on methane and flaring in the upstream oil & gas industry (see table below). Anecdotally we understand that peer companies' definitions of methane intensity are similar but not identical. We are working with OGCI to develop a common standard.

Company	Published Methane Intensity[9]	Methane Target
BP	0.2%	None
Shell	0.5%[10]	None
Total	<0.5%	None
ENI	Not published	80% reduction in upstream fugitive methane by 2025 (vs 2014)[11]
Statoil	0.015% (Norway operated only)	Methane intensity <0.3% across the Norwegian gas value chain[12]
Repsol	Not published	None
XOM	Not published	None
Chevron	Not published	None
Conoco Phillips	Not published	None
Aramco	Not published	None
Pemex	Not published	None

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[9] There is currently no common standard for measuring methane intensity across oil and gas companies.

[10] Figure is from 2015 tight gas operations, not the global portfolio (i.e. comparable to L48).

11 ENI methane target is an absolute reduction target, but a large proportion will be due to a methodology change. Some reduction will come from actual methane reductions.

12 Note this target is a wells to customer based metric, i.e. the full value chain, whereas the published methane intensities of each of the companies in the table are operated emissions only, so tend to focus on well and production facilities

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Further Reading

(Zip file)

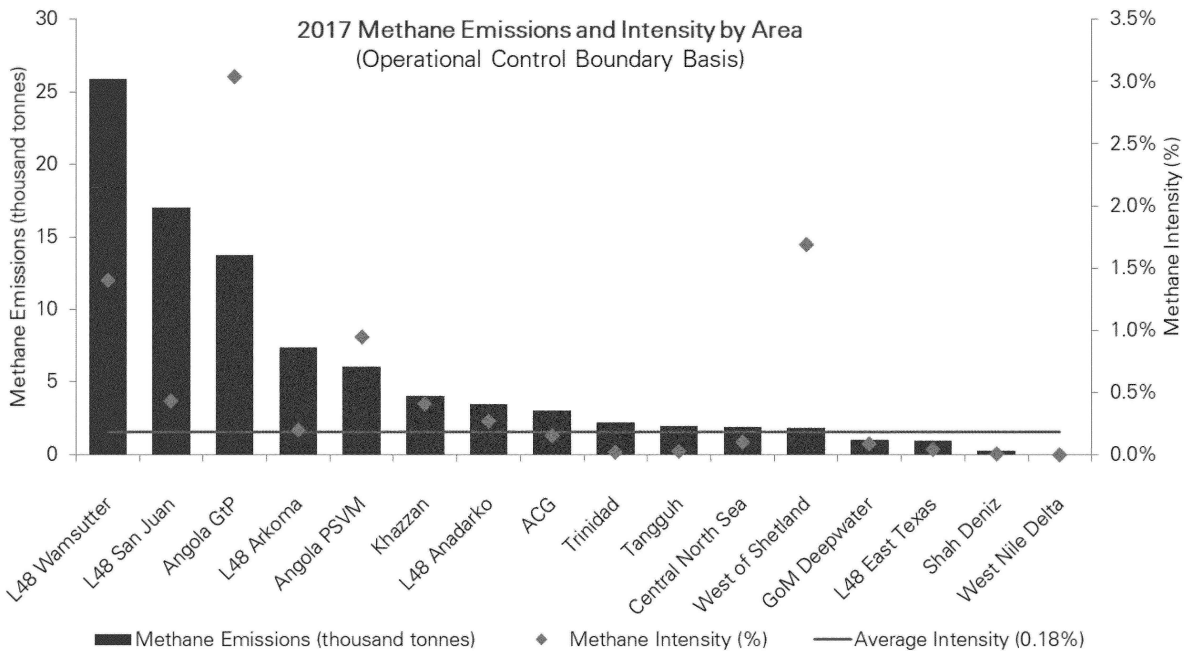
1. An overview of selected external methane initiatives relevant to the oil and gas industry.
2. A description of the methane ‘Guiding Principles’, around which the workshop will be structured.
3. BP’s proposed communications approach for its Upstream gas and methane reduction activity.
4. **IPIECA Methane Glossary** (2018) for further information on methane sources, emission estimation methodologies, measurement and detection methodologies and work practices.
5. **International Energy Agency World Energy Outlook** (2018) Chapter 10 ‘The Environmental Case for Natural Gas’ (Requires a password to access: GroenJaka9224)

- Suggested areas of interest:
  - Some highlights from the chapter: P399
  - The environmental credentials of natural gas (the emissions characteristics of natural gas versus other combustible fuels): P400-403
  - Voluntary efforts (initiatives to reduce methane emissions including learning from leak detection and repair programmes): P419-422
  - Regulatory approach (effectiveness of regulation on reducing methane emissions): P422-423
  - Summary of costs vs benefits (summary of cost analysis of methane mitigation): P432
  - An agenda for action (broad overview of the key considerations and principles that could inform strategies for methane emissions reduction): P433-436

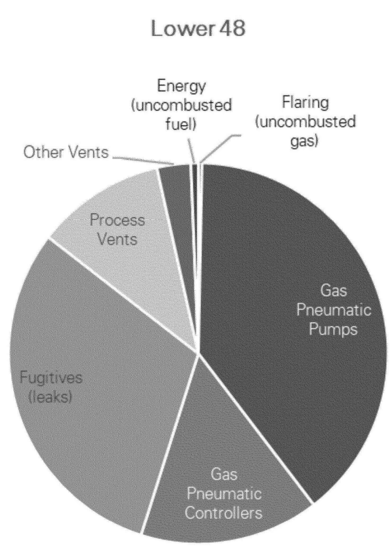
Data Appendix

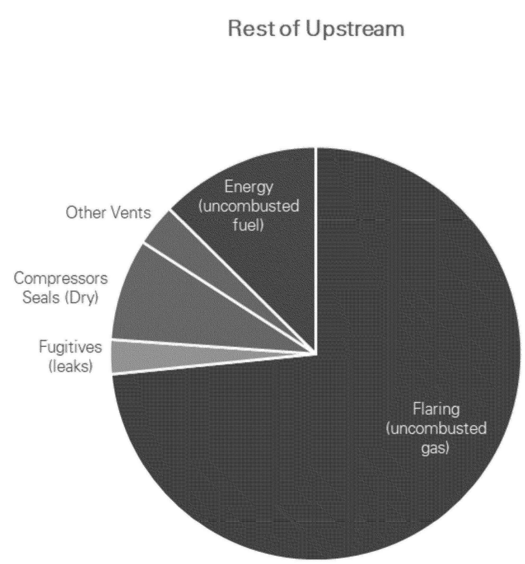
2017 Upstream Operated Methane Emissions and Intensity by Asset

Lower 48 assets have generally the highest methane emissions of Upstream operated assets (on a 100% of operated / operational control boundary basis) – collectively accounting for >50% of Upstream's methane emissions in 2017, with over half of L48's coming from Wamsutter. Performance at other high methane emission assets are generally driven by **flaring** (e.g. Angola due to historical Angola LNG unavailability and Khazzan due to start-up). **West of Shetland** has low methane emissions but high intensity due to low overall gas export.



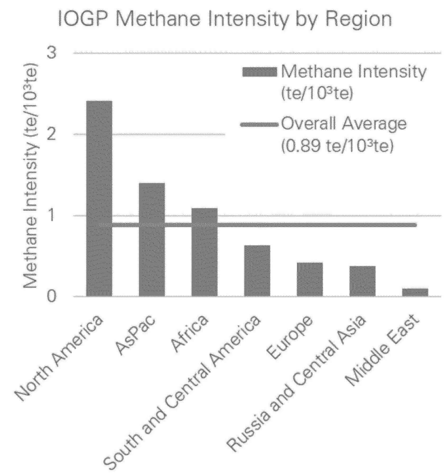
Upstream Operated Methane Emission by Source





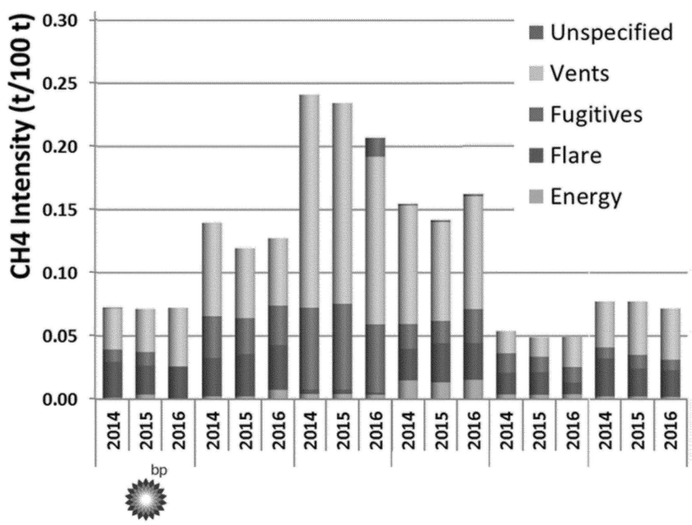
Emission sources split by Lower 48 and Rest of Upstream clearly show the **differences in sources of methane between US onshore operations and other typical oil and gas operations**. **L48** methane emissions arise primarily from **pneumatic devices** (>50% in Wamsutter) and fugitives. Across the rest of Upstream the primary source of methane is **uncombusted gas from flares** (>50% from Angola). The charts are based on 2017 data, but wet compressor seals at FPS have been removed from the Rest of Upstream data following divestment at the end of 2017.

IOGP Benchmarking Data



IOGP Benchmarking Data (published annually in IOGP Environmental Performance Indicator Report, 2016 data shown) shows that, by region, North America has the highest methane intensity largely driven by gas pneumatic device use in onshore gas production. AsPac methane intensity (in IOGP dataset) is driven by venting and Africa is driven by flaring (e.g. Angola). Based on the IOGP data, BP has **slightly lower than average methane intensity** (0.81 te/10³te versus an average across the 18 companies that reported data for 2016 of 0.89 te/10³te).

Global Benchmarking Group Data



GBG data – provided here confidentially, for the purposes of this workshop only - suggests that **BP has relatively low methane intensity compared with our peers** (peer data anonymised due to confidentiality).

- **Vents and Flares** are strongest drivers for CH_4 emissions across GBG peers.
- **Vent** CH_4 emissions intensities are driven strongly by exposure to:
  - Operations using **Pneumatic Devices/Pumps** (US onshore);
  - **Cold Venting/Unlit Flares** (minor source for BP);
  - **Well Unloading** significant source for one company with significant US onshore exposure;
- **Compressor seals** became a more significant in source of fugitive emissions in 2016 due to improved reporting for BP (primarily FPS which was divested at end of 2017) and one other company.
- **Fugitives** are generally lower contributor except one company with portfolio biased heavily towards onshore US, which explains their overall high methane intensity compared to the GBG peers.