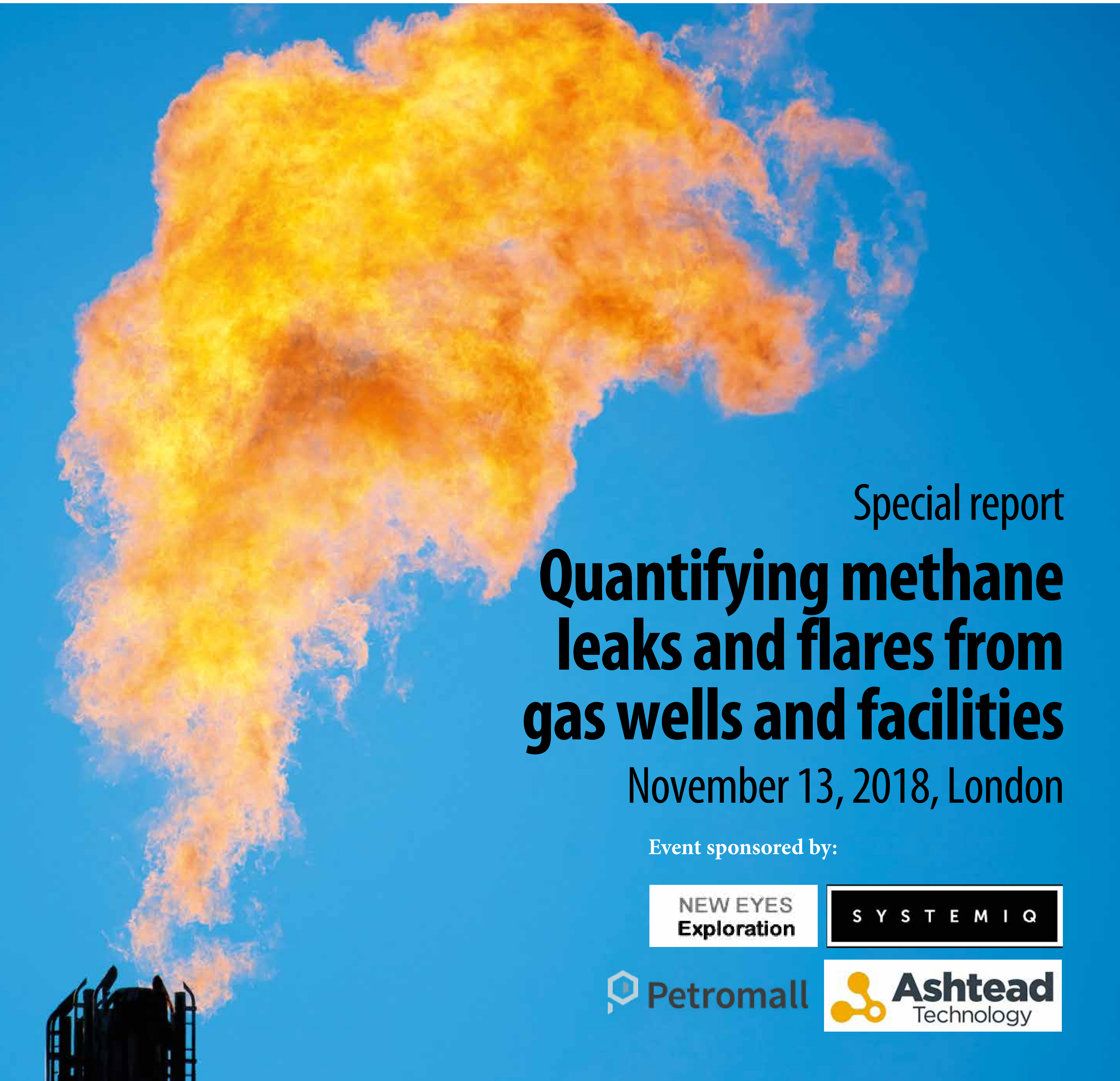
Finding Petroleum

- How OGCI is helping manage methane
- New business models to reduce emissions
- Ways to monetise flare gas
- Optical gas imaging to quantify emissions
- Quantum sensors on drones for methane
- Using lasers for methane
- Measuring methane by satellite

Quantifying methane leaks and flares from gas wells and facilities November 13, 2018, London



Special report

Quantifying methane leaks and flares from gas wells and facilities

November 13, 2018, London

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This is a report from the the Quantifying methane leaks and flares from gas wells and facilities Event, November 13, 2018, London

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Some of the slides and videos from this event can be downloaded free from the Finding Petroleum website event page
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Quantifying methane leaks and flares from oil and gas wells and facilities

Finding Petroleum's forum on Nov 7, 2018, looked at better ways to deal with methane emissions and flaring in oil and gas operations – and how the main step is to understand them better and commercialise them.

Our London forum on Nov 7, 2018, "Quantifying methane leaks and flares from oil and gas wells and facilities", looked at what the oil and gas industry is doing to get a better understanding of its fugitive methane emissions (leaks) and gas flaring, including better ways to measure emissions and ways that waste gas can be monetised.

We heard estimates that about 250bcm of gas, worth about \$36bn, is estimated to be flared, vented and leaked every year. This works out about 7 per cent of all natural gas production. But not much direct continuous measurement is undertaken about fugitive emissions.

Gas flare volumes are measured by meter in most Western operations, but may not be measured in other parts of the world when it is considered a waste product. However can also be estimated from satellite images.

Many oil majors are making efforts to get a better handle on both flares and emissions, to try to demonstrate that gas is a cleaner fuel than coal.

In combustion, gas releases half as much CO2 as coal per unit of generated electricity, and has fewer emissions of SOx and NOx, so has a clear environmental advantage. But without management of potential fugitive emissions and flaring, the argument for gas being cleaner than coal could be weaker.

This leads to concerns at oil companies that unless they make a convincing case that the emissions are very low, there may be less support for the idea of gas as a fuel from governments, who may then create a regulatory environment which disadvantages gas. The issues could also affect the perception of LNG as a cleaner transport fuel.

Fugitive emissions

In terms of measuring fugitive emissions, having a gas safety sensor only provides a small part of the picture. It can tell you if you have gas or not, but cannot tell you when the leak began and how big it has been. And it may miss some emissions if the wind blows the gas away from the sensor.

The oil industry agrees with the need to better understand what they actually emit and try to bring it down – even though there is still uncertainty as to what the current levels actually are.

Norway offshore O&G operations does demonstrate that flaring (and methane) can be managed by the oil and gas industry, having very low levels of both.

On the other hand, some countries like Russia and Algeria have very high emissions, long transmission distances, and very old infrastructure in some cases. But environmental concerns in regulation are lower, and oil companies less beholden to concerned investors, and so there are fewer drivers on the industry to act.

Flaring

Reducing gas flaring and reducing gas fugitive emissions are very different technical challenges. But we cover both together here because the drive to fix both of them is for similar reasons, improving the greenhouse gas 'footprint' of gas production, and to commercialise hydrocarbons rather than waste them.

Companies may flare gas when it arrives intermittently with an oil production stream and they do not have any local gas infrastructure to handle, process or receive the gas. Where regulations permit, flaring gas has always been one way to handle it. This has been happening for decades in many parts of the world, with facilities constructed at a time when gas had barely any financial value at all.

Often there is a lack of funding to build infrastructure to take gas to a market. Sometimes people accept flaring is a problem but it is too far down their priority list, said Mark Davis of SYSTEMIQ.

One delegate mentioned fields he knows which flare 980 barrels of oil equivalent of gas every day to produce 20 barrels of liquid. He said that Nigeria has had an official 'no flare' policy, but has been flaring for 25 years. If you take a flight over Siberia you will see 'forests of gas flares', he said. So there is a pertinent question of why the 'good' sector of the industry should be trying to reduce methane emissions to 0.2 per cent of total production when there is so much wasteful flaring going on elsewhere.

There has been extensive effort in several high flaring regions of the world, with a 7 per cent reduction in flaring reported by World Bank for 2017.

Methane vs CO2

Not everyone agrees on how much you should weigh emissions of CO2 against emissions of methane on a lifecycle basis, because it depends how you factor in the residence time.

One tonne of methane provides 25 times the warming of an equivalent tonne of CO2 in the atmosphere today if you work on a 100 year timescale. But methane has a lifetime in the atmosphere of about 12 years, whereas CO2 in the atmosphere lasts for hundreds of years.

There are limits to scientific understanding into how methane is removed from the atmosphere. The biggest removal process is a hydroxyl radical, but "no-one fully understands how it works and how it destroys methane, why it's been going up and coming down, and what other impacts it has," said BP's Mr Sathiamoorthy. "The biggest sink is the one we understand the least. There's been 20 years of research looking at this."

Meanwhile, SYSTEMIQ works on the basis that a tonne of methane causes 84 times more greenhouse gas impact than a tonne of CO2, because it works over a 20 year timescale – so the impact of methane lasting only 12 years in the atmosphere is less. Based on this calculation, the greenhouse gas impact of methane emissions could be nearly as much as the global total of CO2 emissions.

Event overview

Our forum began with a talk from Muhunthan Sathiamoorthy of BP, speaking on behalf of the Oil and Gas Climate Initiative (OGCI), about how the world's largest oil majors are helping to improve methane detection technology and driving reductions in methane. The talk was followed by Mark Davis from SYSTEMIQ, about how his company is aiming to stimulate activity to reduce emissions and flaring, via investment and setting up new businesses. Chris Lloyd from consultancy Petromall presented some viable approaches to avoid flaring.

Steve Beynon, sales manager North Europe with Flir talked about using Optical Gas Imaging (OGI) cameras to visualise and perhaps quantify methane leaks. Yuri Andersson and Xiao Ai of Quantum Light Metrology talked about using drones equipped with supersensitive quantum light detectors, Andy Connor of National Physical Laboratory talked about NPL's methods for measuring methane (the size of an articulated truck). Deborah Humphreville of Digital Globe talked about monitoring methane by satellite. Finding Petroleum

Note: many of the videos and slides from the talks are available online at **http://www.findingpetroleum.com/event/82610.aspx**

OGCI – how we are helping to manage methane

The Oil and Gas Climate Initiative, a group of 13 oil majors, is improving research and investing in technologies to better understand and reduce to develop ways to understand and reduce methane emissions from the oil & gas industry

The Oil and Gas Climate Initiative (OGCI), a group of 13 oil majors, is investing and running workgroups to develop ways to understand and reduce methane emissions from the oil & gas industry.

Muhunthan Sathiamoorthy, Group greenhouse gas and energy efficiency expert with BP, speaking on behalf of OGCI, explained what the organisation is doing to better understand methane, and why it is important to the industry.

Mr Sathiamoorthy tracks the recent increased interest in methane emissions in the oil and gas industry back to 2014, when a paper was published in the US by the Environmental Defense Fund (EDF), saying that the level of emissions of methane to the environment from oil and gas production could destroy the climate advantage of gas vs other fossil fuels, mainly coal. This paper claimed that 3 per cent of all methane production is emitted to the atmosphere.

Mr Sathiamoorthy said that whilst there are debates as to the actual emission rates, the number itself is not the most important thing. More important is that it has prompted the oil and gas industry to want to get a better understanding of its emissions and find out ways to reduce them.

Sources of industrial CO2 and methane emissions include from gas flaring (incomplete combustion), gas pneumatics (where pressured gas is used drive onshore gas well equipment where no grid power supply is available), and leaks (for example, where seals are not gas tight).

The oil and gas industry is being increasingly asked to take responsibility for its products far beyond the area it has direct control of (upstream). For example it needs to get involved in discussions to support improvements across all parts of the gas value chain, including in distribution – where many of the large Oil and Gas companies do not actually operate. So OGCI is looking into this.

About OGCI

OGCI has 13 members, including oil majors, independent oil companies and national oil companies. As of November 2018 the members were BP, Chevron, CNPC, ENI, Equinor, ExxonMobil, Occidental, PEMEX, Petrobras, REPSOL, Saudi Aramco, Shell and Total.

The members account for 30 per cent of global oil and gas production.

Their participation in OGCI is led by their CEOs, which drives agreements and actions at an accelerated pace.

OGCI "really kicked into action" in 2016 with companies working collaboratively together, learning good practise from each other, and also collectively making investments, Mr Sathiamoorthy said.

The focus is "pretty much upstream", although OGCI has a remit to cover the entire value chain of oil and gas (including midstream and downstream).

Oil companies have more control over the upstream, so that is a good place to start, but the other parts of the value chain should not be left out, he said.

OGCI is supporting research in a number of areas, covering both scientific knowledge and policy. Research funded by OGCI is written by third parties such as universities, so they carry the credibility of the research institution.

OGCI is split into two parts, one part to invest (with a budget of 'at least' $1bn over 10 years), and one part on strategic industry development, through a number of working groups.

Its climate focus is on reducing CO2 emissions (including with CO2 recycling), reducing methane emissions, and improving energy / transport efficiency.

For example, OGCI is supporting a multi-year project with Imperial College, London, to understand emissions from different oil and gas value chains, for example to draw comparisons between LNG, onshore gas production + pipeline, offshore gas + production, coal bed methane production and coal. It will also try to understand the level of uncertainty in the data.

Methane intensity target

In September 2018, OGCI published a "methane intensity" target of 0.25 per cent. It defines methane intensity as the methane emissions to the atmosphere divided by the total marketed gas (which reaches a customer). Gas re-injected into a reservoir is not included as 'marketed gas'.

The full calculation methodology is outlined on the OGCI website. If there is any dispute over how to calculate it, "we go on the conservative side," Mr Sathiamoorthy said.

The 0.25 per cent is a target for aggregated emissions. It is anticipated that some companies will overshoot and some might not reach it.

OGCI's members also have an ambition to get to 0.2 per cent by 2025. Any new companies signing up to OGCI will also sign up to the target.

This compares to current emission levels cited by other groups of as 2-3 per cent. But the numbers are not all made on the same basis, with some covering the whole value chain, others covering just upstream, he said.

0.25 per cent is considered a "pretty good" target by various stakeholders and academics who work with OGCI, he said. It is also not where emissions currently are, according to the oil companies' own calculations.

One academic from Princeton has said, if every oil company could meet 0.25 per cent, there would not be any problem with methane, he said.

"Those technologies will help inform us. Maybe our baseline will change," he said.

Methane measurement

To improve the measurement of methane emissions, OGCI is co-funding a multi-year program of global methane measurement studies, together with the UN Environment, EDF and other parties.

The studies are done independently by scientific experts around the world, and the results will be published. It will experiment with a range of aerial techniques, including drones and different sensors on aircraft.

OGCI has invested in GHG Sat, a company based in Montreal which, in 2016, launched what it claims is "the world's first high-resolution satellite capable of measuring greenhouse gas (CO2 & CH4) emissions from any industrial facility in the world."

"There's a lot of challenges with satellite technology, a lot of learning [to do]," Mr Sathiamoorthy said. "But if it works, and overcomes some of these challenges, then this will provide non-intrusive global methane data. We need to understand this technology. We think it has a role, amongst aerial, drones, ground devices," he said.

Others are also launching or planning to launch satellites to improve methane detection, such as the EDF-led MethaneSat.

Another company receiving OGCI investment is Kairos Aerospace of Mountain View, California, which offers technology to perform aerial methane surveys using a patented spectrometer mounted on light aircraft. The goal is to offer a cost-efficient method to detect significant leaks by surveying large areas and providing data to facilitate deployment of inspection/ maintenance crews to specific trouble spots.

Other OGCI projects

In terms of mitigating emissions, OGCI has invested in Clarke Valves, a company based in Rhode Island, US, which has created shutter valves for flow control with low methane fugitive emissions. The shutter valves offer precise flow control features with low pressure drop and cost benefits.

Mr Sathiamoorthy notes that the oil companies in OGCI can encourage the development of new technology by deploying technology at scale, as well as investing in it, since they purchase so much equipment.

"We're not deploying every single technology, we'll cherry pick the best ones, the right ones," he said.

In June 2018 OGCI held a "Methane Ventures Day", to try to attract people developing innovative ideas, saying, "we have a problem, we want you to help, you come and tell us what you can offer in this reduce / detect / quantify space," Mr Sathiamoorthy said.

Some of the companies highlighted above, such as Kairos and Clarke, were the "winners". OGCI may invest in some of the others if they match its investment criteria.

"We're ready for companies and technologies who are waiting for the next step, where investment and deployment support from OGCI will help," he said.

SYSTEMIQ – new business models to reduce emissions

SYSTEMIQ, an advisory and investment firm seeking to drive system-wide change, is building new technical and commercial solutions to drive down methane emissions from flaring, venting and leaking natural gas.

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SYSTEMIQ is building a platform to enable "low emission intensity" gas to be differentiated in the market place vs conventional fossil gas – building on the trend that many customers are willing to pay more for cleaner products. It is also setting up a technology company which will provide services to reduce methane emissions and turn flare gas into a useful product.

A starting point for understanding the commercial potential is that over the past decades, gas has often been treated as though it is free or value-less, said Mark Davis, senior advisor, SYSTEMIQ. Now it has a greater financial value, a different pathway forward may offer the best economic value.

And if the level of revenue from a project is not large enough to interest big gas companies, the project could be better operated by a third party, taking all the risk and most of the reward itself.

SYSTEMIQ describes itself as an "advisory and investment firm seeking to drive system wide change, mission driven, focussing on delivering the Paris agreement," Dr Davis says.

Sustainable gas market

SYSTEMIQ is looking for ways to develop new market structures which can reward "sustainable gas".

There have been some efforts in the US in this direction, with a ratings agency able to certify gas production as being "sustainable gas". This looks at best practice more broadly, such as asset integrity, facility design and operations, not just methane intensity, Dr Davis said.

In the UK there is something similar with individuals paying a little more for "green" electricity.

One first step to develop a market might be to encourage more awareness about what is going on among gas industrial buyers and consumers, Dr Davis said.

SYSTEMIQ could create a premium price market for "low methane intensity" gas, supported by certification and assurance. Participating in the market would initially be voluntary, but if it works, regulators might use it as a basis for a forcing mechanism, where gas buyers are forced to use it for a certain amount of their gas.

A useful step towards this sustainable gas market would be to improve measurements and standards. OGCI is leading the roll-out of good practice among its members, which account for 30 per cent of oil and gas production, but perhaps SYSTEMIQ could help find out ways to extend this practise among operators which are not members, Dr Davis said.

The weakness in measurement is not the lack of the means to measure, but because the measurement methods are not used, he said. "Only the best world class operators use leak detection and repair programs."

"Many of the technical partners we work with say that where the methane is measured on the ground, the emissions are much higher than are accepted from emissions factors," he says.

"There are bunches of technologies, both aerial and site based, all of which have different strengths and weaknesses, but in aggregate could be put together to find ways of seeing different views of the same puzzle."

Money from waste gas

SYSTEMIQ's other area of focus is looking for ways that waste gas can be monetised.

This might be done by building pipelines to take it to market, converting it to electricity with small turbines, or using to make other products such as CNG, liquid fuels, or as a feedstock for a chemical process.

Mark Davis, senior advisor, SystemIQ

There have been studies by the International Energy Agency showing that about half of waste gas could be monetised with no net cost to operators, Dr Davis said.

SYSTEMIQ is incubating and investing in a company called CH4.Co, which aims to take the problem of oil companies' hands, handling all of the investment and development for a system to monetise the gas, and just giving the gas company a share of the rewards.

To keep its costs down, it aims to use modular, skid mounted, standardised, "plug and play" technology, which can be easily installed and demobilised.
For example for a system to convert gas to saleable liquid fuels.

CH4STOP is looking for projects needing capital of between \$40m and \$50m. "Several million dollars" have been raised already, he said.

"It is our combination of technical expertise and the business model which I outlined which makes us unique," he said. "I think it gives us a proposition people are excited about."

Petromall – ways to monetise flare gas

Flare gas could be monetised through gas storage, improving reservoir recovery, power generation, selling as LNG, selling condensates as liquid fuel, and gas-to-liquid conversion. Chris Lloyd from Petromall shared some ideas

Different ways to monetise flare gas include gas storage (to use the gas at some future point), using it to improve reservoir recovery, generating power from it, liquefying it and selling as LNG, selling condensates as liquid fuel, doing 'deep cut' cooling to extract more saleable condensates from it, and gas-to-liquid conversion, so you can sell liquid fuels made from it.

Chris Lloyd, consultant with Petromall, shared some ideas about how to go about it.

First of all we need to understand a little about how much flaring happens, why, and why it should be reduced.

According to World Bank data, the top flarers in the world volume in 2017 were Russia, Iran, Iraq, the US and Algeria, with the UK at number 21. For example, the UK flared 1.4 billion cubic metres of gas in 2017. Natural gas around the world costs around $1.3 per cubic metre, which gives an indication of how much money goes up the flare stack.

If we look at the flaring in terms of volume divided by the amount of gas produced, the UK ends up worse than Brazil and Saudi Arabia.

Many of these countries see oil as their primary product, and gas as a waste product with little or no value. Flaring is one way to handle it, Mr Lloyd said.

As well as economic and environmental reasons not to flare, there are legal concerns, such as the risk of being sued in future for knowingly causing damage to the environment, as tobacco companies were sued for knowingly harming people's health, Mr Lloyd said. It also damages the image of the industry, and makes the industry less desirable to work in.

But monetising the gas also requires investment, with many wells only being connected to an oil pipeline, not a gas pipeline.

Exploring options

One option is to build a gas storage system, so you can put the gas on the market at a future point when the price is higher, or if you want to use it to help improve oil recovery.

Gas can be stored in conventional gas storage tanks, or stored underground, for example in empty salt caverns. The gas storage tanks can require a lot of 'cushion gas' (gas which will never be recovered), which can be included as part of the capital expenditure of building the storage facility.

The gas might be injected into the depleted oil reservoir at some point in the future, either to keep the reservoir pressure up, or to use the gas to 'clean' the reservoir, producing gas saturated with liquid hydrocarbons left behind in the reservoir, which would otherwise not have been recovered.

Another option is to put the flare gas through a generator to make power, which could be sold or given away locally as a social project, or used to power offices. By replacing the need for diesel generators, you save the cost of diesel, the cost of the generator, and the cost of transporting fuel to the generator. You can also sell heat from the power generation, if there is a need for that locally (this is known as 'combined heat and power, or CHP).

Gas turbines can be as small as 500kW, which can fit inside a shipping container.

If you have larger volumes of gas, you could consider liquefying it and selling the LNG. Although "this does tend to be a big operators game, large costs, long lead times, need for large quantities of gas, reliable gas markets with long term commitments," he said.

But LNG technology is relatively simple, straightforward and safe, although it is relatively energy intensive. It is recognised as a clean energy source, leading to exemptions from carbon taxes in many places. LNG can be sold into a global market, which is growing every year.

Another possibility is to remove liquid condensate from the gas and sell that. This can include propane and butane, which can be popular in many parts of the world as a fuel source, replacing wood and animal dung. You can remove condensate with basic mechanical refrigeration, or may choose to increase your condensate by cooling to -45 degrees in a "deep cut" plant.

Typically you can extract 15 to 50 barrels of condensate per day per million cubic feet of gas production per day.

A further option is using the gas to make a liquid fuel, following the Fischer-Tropsch process, first developed in 1925. The process combines shorter hydrocarbon molecules into longer ones. Typically one million cubic feet of gas will produce 100 barrels of synthetic oil per day. Liquid fuels are easy to transport and usually easy to market.


Chris Lloyd, consultant with Petromall

A number of companies are developing technologies to do gas-to-liquids at a smaller scale, including Compact GTL and Velocys.

"There really are a lot less excuses for flaring at all now," he said.

"These changes in technology mean proven designs are more economic than previously thought."

Factors to consider

When looking to understand the different options for monetising flare gas, you need to consider many factors. This can include the date the gas will come onstream, the components of the gas stream, its pressure and temperature.

You will want to know how much gas is likely to be produced over the lifecycle, and how the gas cut (proportion of the well's production which is gas) is likely to change. You might also want to consider how the gas or liquid prices might change over the lifecycle, and where the market might be. Another factor is the cost of the equipment, he said.

Gas markets vary by geography, and whether it is pipeline gas or LNG.

There can be more than one pipeline gas market, for example the Netherlands has separate pipeline systems for high calorific and low calorific gas, sold at different prices.

Other issues to consider are regulations, tax relief and environmental rules.

Case study

To illustrate how it might work, Mr Lloyd showed some illustrations of a proposed plant in the Netherlands for an oil and gas well. The overall project would only be financially viable with a means of monetising the gas.

The well will produce about 1500 barrels of oil per day, 2.3m cubic feet (80,000m3) of gas per day. The gas contains about 60 barrels of condensate a day.

The oil is piped away directly, and the condensate is removed from the gas and stored in a tank, to be removed by road tanker.

The gas is burned directly in a turbine, to make power for the local grid. The gas can be stored until times of high demand for power (meaning higher price for the electricity).

The gas treatment system is a key component of this kind of plant, he said.

Mr Lloyd also illustrated a "deep cut" plant from an undisclosed location in onshore Europe, which can separate C2 (ethane), C3 (propane), C4 (butane) from C5+ (pentane and longer).

The plant produces 150m3 per day of stabilised condensate, plus some liquefied petroleum gas (propane or butane), and 'overhead' gas used for power generation to run the plant itself.

The plant was originally planned to cost Eur 40m, with costs ultimately Eur 15m after some re-engineering.

Optical gas imaging cameras to quantify emissions

Optical Gas Imaging (OGI) cameras make it possible to 'see' gas leaks. The technology is being further developed to estimate the volume of gas being leaked. But it is more complicated than 'point, shoot and quantify," as Flir's Steve Beynon explained

Optical Gas Imaging (OGI) cameras make it possible to 'see' gas leaks. Using technology developed for Infrared Thermal Imaging cameras, they can 'see' the infrared absorption/ radiation pattern made by different gases, and so show a gas plume on an image.

The technology is being further developed to estimate the volume of gas being leaked. But you need to understand a little about how the technology works to get value out of it, explained Steve Beynon, Sales Manager North Europe with Flir Systems, a company which manufacturers the cameras.

OGI cameras have been used for several years in the oil and gas industry to help find leaks. Their use was usually followed up with other methods, such as sniffers and ultrasonic devices, to assess the size of the leak. But now their data is being used to directly make an assessment of the size of the leak.

The quantification technology measures the size of the plume on the 2D image, and does a calculation to estimate the size of the plume in space. Then it uses other data to estimate how fast the plume is dispersing into the atmosphere (and so how fast gas is going into the plume). Flir does not do this modelling itself, it is done through a partnership with Providence Photonics.

Leaks can be visualised at distances of up to 100 feet. "As long as you've got line of sight that's the key thing," Mr Beynon said.

According to a study by CONCAWE (the European Oil Company Organisation for Environment, Health and Safety), the Qualitative OGI technology had a 6 per cent error rate on average, while a sniffer had a 31 per cent error rate. The testing was done at the National Physical Laboratory.

One of the biggest sources of error is data input by the user, such as wind speed, Mr Beynon said.

Understanding quantification

There are several complexities to quantifying methane emissions.

The camera needs to have a steady image of the emission, so you need a tripod and something stable to place it on. This can be tricky, with some ground or platforms in industrial plants seeing high vibration. There is a continuous mode function that allows the user to determine the best scenario to make a data capture/measurement.

You have to understand how the image on the OGI camera is based on the relative heat absorption characteristics of the different compounds in the atmosphere. Methane absorbs more heat than air (which is why it is a greenhouse gas). Different gases absorb and radiate heat at different frequencies – you the right camera to look for infra-red energy at the frequency of the gas you are trying to detect.

The gas of interest needs to be at least a few degrees delta than the background / atmospheric gas. The greater the temperature difference, the easier the gas is to "see." If you are looking for a greenhouse gas like methane, this can be achieved because methane absorbs more heat from the surroundings.

Different gases have a different level of response, in terms of how they are seen in an OGI camera. For example propane has about three times higher response factor (RF) than methane.


Steve Beynon, Sales Manager North Europe with Flir Systems

There needs to be sufficient 'concentration path length', defined as the distance the gas travels before its concentration in the atmosphere becomes so low it cannot be seen on the camera. If there are high winds blowing gas away quickly, the concentration path length can be compromised.

Different types of release will have a different shape plume, depending on if they are 'point' releases or 'diffuse' releases (from a number of different points). Typically the plume modelling is done by having a boundary on the screen around the leak point and estimating the flowrate of gas across that boundary, so the calculation is messed up if some of the gas passes the circle more than once, however, a masking function can be used to eliminate such scenarios.

To make the technology easier to use, there is an integrated temperature screening tool, to check there is sufficient variation in the energy / temperature between the leaked gas and background atmosphere. There are tools to help you 'see' the plume more easily.

QLM – quantum light sensors on drones

Quantum Light Metrology is placing lasers on drones which can be used to measure methane. By using quantum technology it is possible to make the equipment extremely small

Quantum Light Metrology (QLM), a spin-out company from Bristol University, is using cutting-edge quantum technologies to build sensors that can be mounted on drones for detecting and measuring methane. By using highly sensitive detectors, so sensitive that they can detect individual particles of light, they are able to achieve a much higher sensitivity than conventional devices. The second advantage there quantum technology approach gives the QLM sensors is that they can be made very small, and therefore suitable for fitting on a drone.

QLM was founded in early 2017. It participates in a joint multi-million Collaborative R&D project funded by Innovate UK and has received investment from the investor British Robotics Seed Fund. The project was still in the research phase at the time of the conference (Nov 2018), with a few months to go.

The CEO, Yuri Andersson, has been working with technology and innovation for 20 years, with a number of start-ups, after training as a physicist. He is entrepreneur-in-residence at the Bristol Quantum Technology Enterprise Centre QTEC.

The technology was originally developed as part of an EU funded research project called BRITESPACE, which aimed to build a satellite-based green-house gas monitoring tool. QLM's technical co-founders were some of the leading members of the project who decided to commercialise the technology they had developed.

Dr Xiao Ai, CTO of QLM, has a PhD in electrical engineering from Bristol University, and is an alumni on the Quantum Technology Enterprise Centre (QTEC) programme. He has been working on quantum engineering and sensors for the past 10 years, together with Professor John Rarity of Bristol University, who also serves as Chief Science Officer with QLM, and is considered "one of the founders of quantum optics."

How it works

The system uses a laser and a quantum sensor which can detect single particles of light. This high-resolution sensing makes it possible to make very high precision, high resolution measurements.

It also provides advantages in size, weight and power as the high sensitivity means that less source light is needed. The laser source, sensor, processing and communications technology altogether weigh less than 2kg.

The sensor is able to detect methane from over 50m and at speed to produce a heat map of methane concentrations and with the analysis software that is being developed will be able to build images of plumes and calculate leak rates.

The sensors use spectroscopy, by analysing absorption lines so there is no need for data about temperature and pressure, and therefore eliminates some potential sources of measurement errors. It is also possible to address multiple targets at once through wavelength multiplexing. It can generate a methane concentration image

Dr Xiao Ai, CTO of QLM

in near real-time, which can then be analysed together with wind data to calculate the emission rate. The company is aiming for 1m2 resolution on the image and look to detect concentrations in ppm level.

Deploying it

The company has developed industrial demonstrators, with equipment attached to drones and are looking to scale up production capacity in the near future. They already work with some of the leading a drone inspection company in Oil and Gas for field trials that will test and validate the drones and sensors in an industrial operating environment, the system is very versatile and could also be mounted on a truck or a pole or attached to a tethered drone (which would never run out of battery power).

QLM has partnered with ID Quantique, a Swiss company and world leaders in quantum hardware. The University of Bristol will be developing the 'next generation' of technology relies on 'quantum entanglements', which will work at a broader wavelength range and be able to detect more gas species. QLM is working together with the National Physical Laboratory, which is validating and calibrating their sensor.

QLM is also working on providing a data analytics platform, that runs on data uploaded to cloud servers. This platform allows QLM to build computational fluid dynamics calculation capability, which allows detailed plume analysis.

The same technology can also be used for LIDAR (laser) scans of the ground or structures on it, generating a 3D image of whatever the drone can 'see', with half a metre resolution. Additional applications for the technology in Oil and Gas exploration are being evaluated, including with a device fitted to a fixed wing unmanned aerial vehicle.

National Physical Laboratory – using lasers for methane

The UK's National Physical Laboratory (NPL) has developed a sophisticated laser based technique for detecting and quantifying Green House gases (including methane) and atmospheric pollutants. Higher Research scientist Andy Connor explained how it works.

The UK's National Physical Laboratory (NPL) has developed a laser based technique for detecting and quantifying Green House gases (including methane) and atmospheric pollutants, called Differential Absorption LIDAR (DIAL). DIAL provides full spatial data of emissions from unit level to full site. It can be deployed to a wide range of sites (including petrochemical), is mobile, self-contained and housed in an articulated trailer.

The technology has been under development for 30 years and offered as a commercial service for 25 years, said Andy Connor, a scientist with NPL's emissions and atmospheric metrology (measurement) group.

NPL is also developing a distributed sampling technique for the continuous measurement of methane, which currently samples methane concentration using an accurate reference source (for example a Cavity Ringdown Spectrometer) from around a facility via long tubes. NPL has a 'controlled release facility' which can be used to validate techniques, sensor technology and protocols.

The organisation's main role is developing and applying international measurement standards, working in many industrial sectors. It often finds itself between academia and business, not just developing core science, but developing the systems, standards, protocols and procedures to use scientific methods in an industrial environment, Mr Connor said.

DIAL

The DIAL (Differential Absorption LIDAR) technology can be described as similar to radar, in that it sends radiation to an object to see what gets reflects back, but it uses light instead of microwaves.

A powerful laser, tuned to a specific wavelength, is 'fired' into the area of interest. Some of it gets scattered by aerosols and particulates in the atmosphere, and a portion of the light is reflected back to a telescope and detector.

As a rough sense of scale: For every 10 to the power 10 photons transmitted, only one comes back, Mr Connor said. So there needs to be quite a powerful laser and a large telescope to collect enough return light to get a good signal to noise ratio.

The laser is transmitted at two wavelengths, one to be absorbed by the gas of interest, the other not. The two return signals are then compared. The wavelengths need to be quite close together, to minimise the impact of any atmosphere effects. The gas concentration is obtained from the ratio of the returned signals, along with information about the laser power and gas absorption coefficient.

When monitoring a methane emission, you need to know the level of methane in the background atmosphere, so you can see what the difference is.

To calculate the emission rate, the gas concentration is combined with wind data, so you need to know the wind speed and direction. By measuring wind speed and the methane concentration across the measuring plane, you can work out emissions rate in kg per hour.

Ideally the laser will measure perpendicular to the wind (with the laser cutting through the emissions plume).

The laser is fired at a number of different elevations, and azimuths, with an average taken of multiple 'firings'. Altogether carrying out a measurement takes less than 20 minutes.
DIAL can operate at a sensitivity down to less than 1kg / hour.

So far there is only one mobile DIAL unit in operation of its kind, and it is housed in a 30 tonne articulated truck. As well as offering a commercial measurement facility the system was also designed as a research facility, and laid out with plenty of space to do experiments.

But businesses might prefer a system which is cheaper to transport and more manoeuvrable. So NPL is developing (but yet built) a lighter and smaller version of the DIAL. A design goal is that the system can be used with less skilled operators – the original requires a laser physicist onboard. The data can be transmitted back to NPL for processing.

The current system is also designed to measure a wide variety of different gases. If it was designed just for the methane wavelength it could be possibly reduced in size further.

Andy Connor, scientist with NPL's emissions and atmospheric metrology (measurement) group

The system has been used for detecting many different gases, including volatile organic compounds (VOCs), benzene and NOx, as well as methane. It is used for compliance and research.

It has been used on a number of small oil and gas facilities, typically about 100m x 50m in size as well as large scale facilities.

There is also a distributed sampling technique, consisting of an accurate reference instrument, for example a cavity ringdown spectrometer, which takes ambient air from around the site through tubes (2-300m long) into the device. The current system samples from about 12 locations for 5 minutes at a time.

NPL is looking at lower cost sensors, which can be placed around the site, to initially compliment the sampling tubes, extend the range where it would be in practical to deploy tubes and fill in the temporal gap in the data. Eventually it is envisaged that low costs sensors would replace most of the tube sampling points.

Other projects

Another area of research for NPL is low cost, small and light methane sensors, made with metal oxide semiconductors (MOS). The device changes electrical resistance in the presence of gas such as methane. The devices are sensitive to temperature and humidity, so you might want a separate temperature and humidity sensor to work out how to remove those effects.

NPL also has a "controlled release facility," a system containing a tank of gas of known concentration, and mass flow controllers. It is possible to emit methane to the atmosphere in a known concentration and flow rate from up to four different nodes, for testing out sensors and to validate techniques. It can simulate different emission scenarios, such as a leak or faulty seal or a diffuse emission source.

Digital Globe – measuring methane by satellite

Researchers have shown that it is possible to see methane from space, but there is ongoing work trying to see if it is possible to quantify emissions, says Deborah Humphreville, director energy EMEAR with DigitalGlobe, a Maxar company

If you could measure methane emissions using satellite imagery, that would solve a lot of the problems – there could be a database of all of the methane leaks in the world and who is making them – making it easy to focus resources on reducing them and reward companies with the lowest emissions.

So far, research has shown it is possible to see methane in satellite imagery, but quantifying it is still a work in process, and it depends on what level of quantification you need, said Deborah Humphreville, director energy EMEAR with DigitalGlobe, a Maxar company. The company specialises in space imagery.

There have been times when analysts thought they could see a plume (methane release) but they were just seeing 'incumbent' methane (which was there before).

Understanding flaring is much easier than emissions, because they show up very clearly on the images. Satellite imagery has been used to identify and quantify flaring for many years, by a number of different government satellite agencies.

But for tracking methane, you would need a camera on a satellite similar to the optical gas imaging cameras, but capable of operating over at least 700km (instead of 50m) and at a very high speed (not focussing on the same point for a few seconds). There are also limitations in space of how large a camera can be installed.

Deborah Humphreville, director energy EMEAR with DigitalGlobe

The data needs processing. One challenge is removing noise generated by the atmosphere between the ground and the satellite. Also the wind speed, temperature and other weather factors need to be taken into account in the calculation.

To be sure you are seeing an emission and not background methane in the atmosphere, you need imagery of the same point on Earth before and after the emission took place.

One challenge is that satellites can only monitor emissions when they are actually flying overhead, and it can't just be called to fly overhead when it is needed. People say they would like the same place on Earth to be monitored twice a day, or might like hourly data if it was available.

The camera needs sunlight to work, so it needs to happen in the day.
Some people have raised the issue that people could emit methane during night time, then it could never be seen by a satellite.

There are projects to launch satellites specifically for tracking methane, including MethaneSAT being launched by the Environmental Defense Fund.

There are commercial motivations for monitoring greenhouse gases from satellite, including the idea that there might be fines for emissions, so a value to having control over what you are doing. Companies might pay for data about leaks so they can fix them quickly.

The data can be sold by direct access to a data stream, or by subscription. People might want to merge satellite data with their in-house data.

Behind the push to satellite imagery are the enormous advances with satellite technology in previous years, with many more satellites being launched, with a smaller size, and commercial-of-the shelf technologies.

Science missions have provided valuable insight into the need for the development of commercial GHG satellite sensors that are designed for operational missions that can support customers' needs with relevant, meaningful, useful and defendable data and analytics, she concluded. "DigitalGlobe a Maxar company and its partners' expertise can provide thought leadership in this endeavor."

What did you enjoy most about the event?

Technically focused engaging audience.

Networking, and gaining a wider perspective. The presentations on methane detection by drone and by Ashtead Technology were particularly useful to me for their applications in upstream hydrocarbon exploration in the field.
Mike Rego (PetroMall Ltd)

Important but seldom addressed topic.

That it stayed on topic. *(Plexus Holdings)*

Application of OGI camera for VOCs emission.

The OGCI overview was probably most useful for me.

Range of speakers and perspectives.

The opportunity to talk to a variety of different experts with a shared interest in the topic of methane emissions. Good to have all these themes under one banner.

All presentations were very interesting.

Good presentations and overview of the topic as a whole.

Quantifying methane leaks and flares from gas wells and facilities November 13, 2018, London, Attendees

Hugh Ebbutt, Director, A T Kearney

Paul Murphy, Key Account Manager, Oil and Gas Division, Airbus Defence and Space

Matthijs van der Kooij, Business Development, Airbus DS NL

Rebecca Stanley, Digital Marketing and Business Development Manager, Ashtead Technology

Josh Thomas, Senior sales manager, Ashtead Technology

Sonna Sathiamoorthy, Group GHG and Energy Efficiency Expert, BP

Susan Ford, Senior Advisor Environment & Carbon, BP

Will Jeffery, Senior Offshore Interpreter, CGG

John Glass, MD, Cloverfield Consulting Ltd

Micky Allen, Consultant

Diwin Amarasinghe, Geophysical Specialist, Consultant

Dan Kunkle, Director, Count Geophysics

Deborah Humphreville, Director Key Accounts EMEAR, DigitalGlobe

Stephen Norman, Business Development Manager, DNV GL

Wayne Youngs, Division Europe/CIS, Enerflex

Nnamdi Anyadike, London office, Energy Correspondent

Martin Riddle, Technical Manager, Envoi

Chris Hazell-Marshall, Principal Consultant, ERM

Malcolm Brown, Director, Euhedral Energy

Maurice Eaton, Consultant, Explore Oil

Karl Jeffery, Editor, Finding Petroleum

Avinga Pallangyo, Events Manager, Finding Petroleum

John Leggate, Managing Partner, Flamant Technologies

Steve Beynon, Sales Manager North Europe, Flir Systems Ltd

Johnnie Shannon, Senior Remote Sensing Consultant, Geospatial Insight

Nick Steel, Independent Consultant

Manouchehr Takin, Independent Consultant

Christian Bukovics, Independent Director, JKX Oil&Gas Plc

Juyoung Jeong, Manager, KECO (Korea Environment Corporation)

Minseong Lee, Staff, KECO (Korea Environment Corporation)

Gitae Park, Interpreter, KECO (Korea Environment Corporation)

Andy Connor, Higher Research Scientist, National Physical Laboratory

Mike Rego, Independent Consultant, PetroMall Ltd

Christopher Lloyd, Consultant, PetroMall Ltd

Henry Dodwell, Consultant, PetroVannin

Graham Stevens, Finance director, Plexus Holdings

Dr. Xiao Ai, CTO, Quantum Light Metrology

Yuri Andersson, CEO, Quantum Light Metrology

Samia Ahmed, Geologist, S A Consultancy

Jeanne Martin, Senior Campaigns Officer, ShareAction

Alex Elson, Shell

Mark Davis, SYSTEMIQ

Alessandra Kortenhorst, Associate, SYSTEMIQ Ltd

Katie Routledge, Terrabotics

David Offer, Consultant, Trinucleid Geoscience

Yuri Leonenko, Professor, University of Waterloo

Pete Floyd, Senior Manager Upstream, Wipro