METHANE MONITORING DEEP DOWN UNDER

Commercial diving activity in Asia Pacific

Optical gas imaging or fixed fuel-cell gas detectors for methane leak detection? Open path infrared gas detectors or portable PPE devices for site and personnel safety? Tunable diode lasers or cavity ring down spectroscopy for measurement of methane in ambient air? Methane monitoring in environmental, mining and natural gas processing sectors is essential across several applications and the array of available measurement techniques is broad. The armoury is full but picking the most appropriate weapon is relatively easy with a few pragmatic considerations.

Coal in hands

Coal seam gas

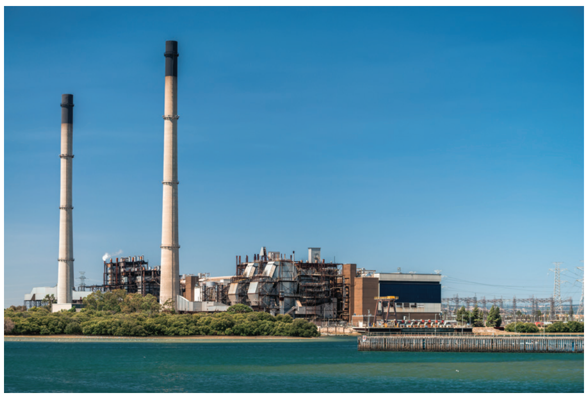
In Australia, a wave of natural gas exploration has been taking place in Queensland, New South Wales and farther offshore. The deposits of natural gas in eastern Australia often exist as coal seam gas (CSG). Whilst the extraction of shale gas, as has become common in the USA, relies completely on the use of fracking to release trapped natural gas, CSG is more readily accessible and perhaps only half of the sources require fracking to stimulate the gas flow.

The presence of natural gas in the Australian coal seams presents economic potential. However, underground methane has not always been regarded as a potential source of wealth. In the early days of coal extraction, it was rather experienced as a hazard and miners in the Illawarra Bottoms coal fields were only too aware of the risks of exposing a large pocket of methane or carbon dioxide during underground drilling operations. The methane gas detection technology available to miners today which uses fuel-cells in fixed and portable devices to detect flammable gases can help to minimise the risks significantly. But, these gas detection devices were not in common usage on the 24th of July 1979 when a massive methane explosion ripped through parts of the Appin coal mine 600m below the surface of New South Wales killing fourteen miners. The judicial inquiry that followed the accident recommended continuous gas monitoring equipment should be used in mines in the future. This was a major turning point in the history of underground gas detection and mining safety.

When choosing a gas detector for mining applications several criteria must be met. Firstly, the gases to be detected must comply with the local safety legislation and any additional practices in place in the mine. At a minimum, this would typically involve simultaneous measurement of methane, carbon monoxide, hydrogen sulphide and oxygen. The device must also be intrinsically safe and thereby avoid creating additional ignition risks. Beyond that, many factors come into play such as the robustness of the unit, its weight, the ease with which the functional test can be performed, data capture for audit purposes and battery life.

LNG exports fuelling major economies

CSG can be converted to liquefied natural gas (LNG). In addition to LNG production on the east coast of Australia, the Browse basin and the Gorgon gas fields off the north and west coasts are also active LNG producers with regular shipments to Asian energy markets in Japan, China and South Korea. Safe transfilling of the LNG from the production stations to the tankers and the subsequent shipping of natural gas relies on natural gas leak detection systems, many of which are open path type gas detectors. These use infrared light to detect methane, which is an infrared active molecule. Open path gas detection devices differentiate from each other in the way they compensate for the potential influence of fog and rain and their resistance to solar interference. These are important considerations in offshore applications where the bright Asian sun and tropical storms alternate to dominate the weather pattern.



Natural Gas Fired Power Station in Port Adelaide, Torrens Island, South Australia

Miner overcome by grief

Shale gas extraction has revolutionised the US economy in the past 20 years and the impact is being felt worldwide through the export of products, such as ethane shipments to European and Asian Ethylene crackers. In the past, the USA was a heavy importer of natural gas from Canada. This flow of gas is still important to both economies, but the USA is now also a natural gas exporting nation, in the form of LNG exports from the Gulf Coast. The abundance of natural gas has also led to the balance of US electrical power generation moving from coal as the staple feedstock to a more even balance of natural gas and coal combustion.

Fixed flammable gas detection

Natural gas power plant protection

In terms of carbon dioxide emissions from electrical power generation, the combustion of natural gas yields approximately 0.5 kg of carbon dioxide (CO_2) per kWh of electricity produced: approximately half the amount of CO_2 emissions per unit of electricity than coal combustion. This means that the global warming caused by natural gas combustion is less than the impact from coal fired power generation. In comparison to coal, natural gas also produces fewer environmental pollutant gases such as mercury, sulphur dioxide and hydrogen chloride when burned, making the clean-up of the flue gas much simpler and less expensive. These environmental benefits, combined with the abundance of natural gas and its ease of distribution, have led to it replacing coal in many national power generation strategies in recent decades.

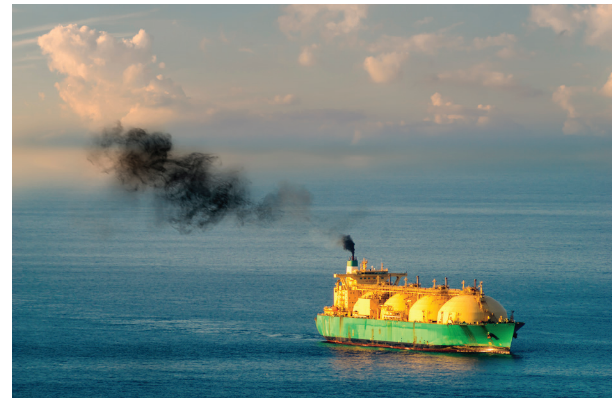
To ensure that natural gas power plants may operate safely, an array of methane gas detectors are used to identify leaks before the flammable gas could potentially accumulate to dangerous levels. Fixed gas detection systems are used close to high risk leak areas such as gas compression stations, rotating machinery and pipework flanges. Open path detection systems are often chosen for the task of monitoring large unobstructed areas of the facility. The most sophisticated open path systems have lasers that are safe for human eyes and use harmonics in the optical detection methodologies to maximise their sensitivity to methane and thereby minimise the risk of false alarms being triggered by other inert gases.

Methane emissions monitoring from gas-fired power generation

Research into methane emissions from natural gas turbine power plants operating at steady state has indicated that up to 0.2% of the natural gas fed to the plant is emitted due to incomplete combustion. During start up, this has been shown to increase to a level up to 2.5%. To conduct this study Cavity Ring Down Spectroscopy (CRDS) instrumentation installed in a small manned aircraft was used to over-fly 14 natural gas fired power plants in the USA[1]. Due to the long path length of the light beam, this laser adsorption analytical technique is one of the most sensitive methods for the detection of trace concentrations of small gas molecules such as methane, carbon dioxide and ammonia which are optically active in the near infra-red region. Adaptations, of the CRDS technique, such as the Off-Axis Integrated Cavity Output Spectroscopy have further enhanced its range of applications in environmental detection and these analysers can now be used for permanent land-fill gas emissions monitoring where they analyse trace levels of methane and other landfill site greenhouse gas emissions.

Australia energy mix

As an alternative to large turbines, gas engines are suitable for smaller power generation applications in the 5 to 20 MW range and are often coupled to biogas facilities or anaerobic sludge digesters to produce power from the biologically produced methane. They use positive displacement pistons and work in a similar way to petrol-fired car engines. They also benefit from very low start-up times in the range of 3 to 5 minutes, which compares favourably to the 20 to 30 minutes that may be typical for a gas turbine power plant cold start. This rapid response can increase the flexibility of a power generation network to respond quickly to power demand peaks. Methane leak detection around such equipment can be readily achieved using a fixed gas detection system with a fuel cell type detector: these are readily available, low cost devices.



LNG exports

Methane monitoring and big-data improve gas pipeline operations

Modern wearable natural gas detection units combine location tracking using cell-phone type GPS technology with cloud computing and big-data at their base station. This combination of features enables gas distribution operating companies to gather gas detection data from the devices worn by their employees. Maps can be generated which provide a clear indication of where gas-leak trouble spots exist. This ongoing data gathering is especially effective when used over a long period of time by teams of operators. It can be highly valuable for data gathering in urban areas where the gas distribution grid may be aged or where frequent construction related excavation works make the pipeline vulnerable. Low value data can become highly valuable management information about maintenance requirements which enables the repair of gas pipeline leaks to be prioritised and thereby ensuring cost-effective and safe operations.

With much of Australia having ideal sunlight conditions for an abundant supply of solar energy, the concept of using electrolysis for power to hydrogen is highly attractive. For the past year, Hydrogen produced in this way has been injected into the natural gas distribution grid in Western Sydney at low levels. As the world's dependence of fossil fuels gives way to the emergence of renewable energy sources for power and heat, hydrogen gas transmission grids will become more important in the future… and gas leak detection will remain an essential aspect of gas distribution pipeline oversight through the energy transformation for decades to come.

1 Observations of Methane Emissions from Natural Gas-Fired Power Plants, Kristian D. Hajny et al, Environ. Sci. Technol. 2019, 53, 8976–8984.

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