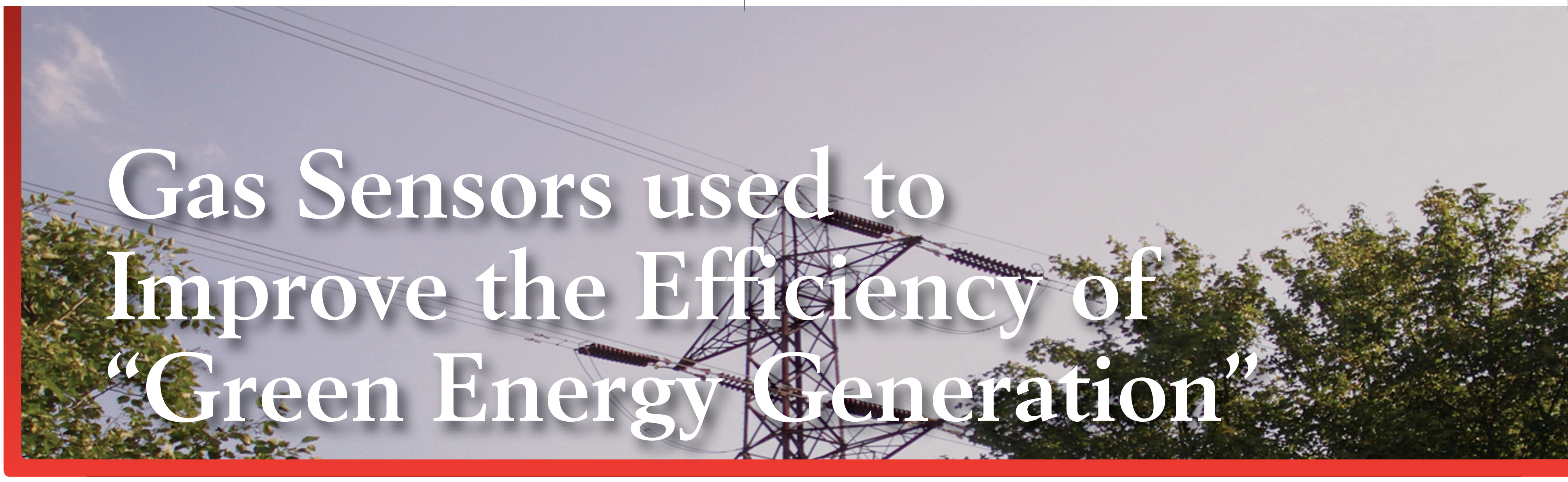


Gas Sensors used to Improve the Efficiency of "Green Energy Generation"

Growth in Biogas Electricity Generation

The generation of electricity from biogas is becoming ever more popular, driven at least in part by the introduction of government set feed-in tariffs and other green project initiatives. A prime example of which comes from Germany, one of the first countries to introduce a "feed in tariff" scheme around 10 years ago, resulting in a significant number of biogas plants being built. The countries that were first in the introduction of 'feed in tariff' schemes are also early adopters of biogas energy, have driven several green projects promoting the installation of biogas plants and supported the continued growth within the biogas industry. The 'feed in tariff' schemes guarantee a minimum tariff payment to the generation plant owner, usually fixed for a long period, 5 to 10 years, or more, is not uncommon. The guaranteed minimum tariff is used as an incentive to support the return on investment on the large upfront costs required to purchase and install such plants.

In the last 20 years, biogas utilisation has been successful in wastewater treatment plants, industrial processing applications, landfill and the agricultural sector. The future increased use of biogas energy is a strong goal in most countries, not only because is it a renewable energy source but it will help in the reduction of greenhouse gas emissions, water pollution and soil degradation and it may influence agriculture sectors worldwide to produce green energy. Adoption of biogas production is growing and is supported by many countries looking for green alternatives to generate electricity for heating and lighting and as a fuel for motor vehicles to deliver goods and public transport.

It is important to ensure the quality and efficiency of the biogas produced as, before it can be used in the generation of electricity or in converted vehicles, it must be cleaned and converted to bio-methane.

What is Bio-methane?

Bio-methane is a cleaned version of biogas which is created from the natural processing of decomposing waste material in an anaerobic digester system. Anaerobic digestion is the natural breakdown process of any organic substances from animal or plant origin like household rubbish, food scraps from kitchens or food process plants etc.

The waste material is placed in a sealed large vessel, where anaerobic bacteria (those which function in a non-oxygen environment) decomposes the waste material producing and releasing gases like methane and carbon dioxide over a period of time. Biogas is generated from many sources of anaerobic digestion of waste, such as:

- Landfill sites
- Wastewater treatment facilities
- Food processing plants
- Large livestock farms
- Vegetable matter
- Meat waste etc

Biogas production

Raw biogas produced from anaerobic digestion is flammable when mixed with air or oxygen, but is not of a high enough quality for gas resale or for the use of electricity generation. For biogas to be used to generate electricity, power cars or to be fed on to the national gas grid, it will need to be cleaned up or "Upgraded" and converted to bio-methane.

Upgrading

This process is used to remove the carbon dioxide, hydrogen sulphide and other contaminants which normally appear in biogas and which could easily damage the biogas machinery or limit the efficiency of electricity generation. The presence of hydrogen sulphide and high humidity will create corrosive acid which is strong enough, over a period of time, to corrode and damage the very expensive generation equipment.

Biogas upgrade facilities are also used to improve the quality of the biogas to meet the natural gas standards. These are the standards set by the gas industry to ensure the quality and calorific value of the gas fed in to the national gas grid. The consumer is therefore guaranteed then

Typical Contents of Raw Biogas

Compound	Chemical Symbol	% Volume
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-2

amount of heat energy given off per litre of gas burnt. The upgrade system creates a purified biogas that is now called bio-methane, which can now be used to power modified vehicles or alternatively used to generate electricity. The electricity generated can be used locally or be fed back into the national grid to earn the feed in tariff payment. There are many process methods that can be used to upgrade biogas some of these include pressurised water scrubbing (PWS), pressure swing adsorption (PSA) and other chemical treatments.

Pressurised water scrubbing (PWS)

This is a physical absorption process where raw biogas is forced through a pressurised water tank. The carbon dioxide and some of the other gases like hydrogen sulphide and ammonia are absorbed by the water. This is the most common process used for upgrading biogas, especially in Europe.

This pressurised water scrubbing process can deliver 99% methane with the manufacturer guarantee of a maximum 1% methane loss in the system.

Pressure Swing Absorption (PSA)

This process cools the gas to very low temperatures, which forces the water in the biogas to condense and separate from the gas. Carbon dioxide is then removed by the use of active carbon materials to absorb the carbon dioxide and leave just the bio-methane.

Other chemical treatments

Other treatments utilises the pressure washing technique (PWS) but with the addition of a washing fluid as an additive to the water. The chemical additive increases the efficiency of removal of the carbon dioxide, hydrogen sulphide and other contaminants. A heat regeneration process is required to maintain the performance and keep the additive in the best condition. A replacement is required approximately every 10 years. Other chemical processes can involve washing the biogas with monoethanol amine (MEA) or diethanol amine (DEA) to again remove the contaminants and leave just the bio-methane.

The efficiency of the electricity generation is dependent on the quality of the bio-methane and the upgrading process. To ensure this process is effective for the efficient generation of electricity and to prevent damage to expensive equipment, measurements are required for the percent volume concentration of the methane and carbon dioxide plus the measurement of the ppm levels of corrosive gases like hydrogen sulphide. Gas generation efficiency is not mandatory for your personal generation needs but is recommended by the generator engine manufacturers to produce the best efficiency.

It is vital to check on the corrosive gas concentration in order to prevent permanent damage to expensive equipment and the overall plant safety due to gas leaks and the possibility of explosion.

The more efficient the upgrade process, the better efficiency of the generator and the more electrical units are generated from the same volume of gas. This reflects in higher revenues from the electricity fed into the national grid. This in turn will create a faster return on the large initial capital investment in the biogas plant.

What sensor technology could be used to monitor the biogas upgrade?

A method of ensuring the efficiency of the above process can involve the measurement of the gas concentration before and after the upgrade process. Methane and carbon dioxide volume gas measurement is generally carried out by gas monitoring systems, which utilise either thermal conductivity or infrared gas sensor technology.

Thermal conductivity sensors are low cost and easy to use but are only recommended to be used to monitor methane or carbon dioxide separately due to the sensors cross sensitive to both gases. Thermal conductivity sensors consist of two fine wire platinum coils, so the fragility of the thermal conductivity sensor will need to be a consideration on the sensor suitability, low cost is not always the best solution.

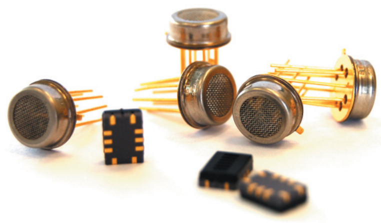
Infrared sensors are now miniature in size and are very effective in the measurement of percent volume methane and carbon dioxide without any of the cross sensitivity issues which are apparent in thermal conductivity sensors. Infrared sensors are slightly more expensive and require more thought in the electronics design to use, but they do offer the ability to measure both methane and carbon dioxide at the same time and now with the availability of "plug and play" electronic development kits. Infrared sensors also offer a more precise long term solution. This is certainly the case with new infrared sensors being developed specifically for biogas applications such as the new dual gas infrared sensor option from manufacturers such as e2v technologies. The IR15TT-R dual infrared gas sensor allows the user to monitor methane and carbon dioxide at the same time, utilising two independent channels fitted into a 4 series 20mm diameter package resulting in a much lower cost than two individual sensors.

The IR15TT-R sensor, which is specifically designed for the biogas application, can be combined with the IR-EK2 development kit so that any instrument manufacturers can be competently taking infrared gas measurements on their own PC within minutes.

Monitoring the hydrogen sulphide level in raw biogas requires the use of a different technology sensor as the gas concentration levels are much lower, parts per million (ppm). In this case electrochemical cells are normally used. For oxygen measurement there are two main types of electro chemical oxygen sensor technology available today.

The older sensor design is based on lead acid battery technology, whereas the newer sensor design is based on a lead-free oxygen pump technology. The older lead based sensors have a fixed life time set by the sensor internal volume, the sensor output current and how much lead wire (gog) can be crammed inside the sensor, the maximum life time is approximately 3 years in the current sensor types. The new oxygen pump technology sensor has some major advantages over the older lead based sensor, such as there is no consumption of any materials within the sensor, the sensor life expectancy is > 5 years and being RoHS compliant it is ready for the future.

There is however a requirement for a constant low voltage bias to be connected to the sensor just like other biased toxic electrochemical cells. Currently the new pump technology type of oxygen sensor is only available from one sensor manufacturer e2v technologies.



The environment within the bio-digester can be harsh and all of the sensors used will need to be designed to meet that challenge, robust sensors in stainless steel housings and inert gold optic construction are recommended.

All gas sensors used within this environment are classed as electrical components and they will need to be tested and approved as an electrical component fit for use in hazardous area locations.

The sensors can be Ex or Intrinsically safe for use and they will carry certification marking of the approval usually UL, ATEX, CSA, or a national standard of the country where the plant is fitted. Biogas can be explosive if mixed with air or oxygen in the correct concentration and is considered a hazardous environment where an explosion could occur.

For further information on sensors that are applicable to biogas applications or industrial and air quality applications please visit www.e2v.com/gassensors and download the e2v air application.

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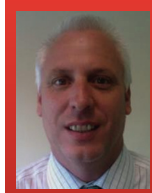

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