Biogas capture, storage and combustion

Biogas is the product of anaerobic biological breakdown of organic substances. It is produced by any anaerobic technology when conditions are suitable for methane production and can be generated by bacteria from organic waste solids (in digesters) or from wastewater containing organic material.

Anaerobic ponds or lagoons are a common treatment step of wastewater produced from the meat industry. The technology is simple and inexpensive to operate while significantly reducing the wastewater organic loading. Captured biogas can be used to fuel a boiler or to produce electricity and waste heat in a co-generator. The burning of the biogas also significantly reduces carbon emissions. Hence, the covering of the anaerobic ponds has recently become popular.

Biogas capture systems have two roles:

1. The incineration of biogas generated by the CAL to ensure the methane content of the biogas is converted by burning into carbon dioxide. Methane has a global warming potential of 21 times carbon dioxide.
2. To ensure that simultaneously all gaseous compounds with an offensive odour (H_2S especially) are oxidised to odourless components. Where the biogas is used for cogeneration in a biogas engine, or diverted for boiler fuel, the flare exists as a contingency element of the system only.

Components of a biogas capture and delivery system

A biogas capture, storage and combustion system typically consists of a Covered Anaerobic Lagoon (CAL) and a biogas train to deliver biogas to the flare, boiler or co-generator. A CAL typically consists of:

- An earth dam with an impermeable liner.
- A cover which is fixed in place by an anchor trench or a concrete ring beam.
- Wastewater inlet and outlet pipes designed to allow the wastewater to enter and leave below the pond surface.
- A biogas collection ring main around the lagoon perimeter and under the cover, which is used to collect the biogas. The ring has single or multiple discharge points through the cover or liner.
- Biogas release valves that are a safety feature to release gas that is unable to exit through the collection ring. This generally happens when pre-set pressure under the cover is exceeded. For example, if there is a blockage or prolonged flare shutdown.

Table 1: Types of biogas release valves

Simple pipe spears

Image: NB Foods, Oakey

Water seals or hydrostatic valves

Image: Teys, Beenleigh

Weighted flaps

Images: Kilcoy Pastoral Company Limited, Kilcoy

- A weighting and stormwater removal system which works together to minimise stress to the pond cover. The weighting system firstly minimises wind forces on the cover and provides low spots for water accumulation. The stormwater removal system pumps the water away from where it accumulates. Excessive amounts of accumulated stormwater reduce gas storage space and can block pipes or biogas flow under the cover.
- Inspection or sample points or manholes.
- A sludge removal system may be installed to periodically remove accumulated sludge.

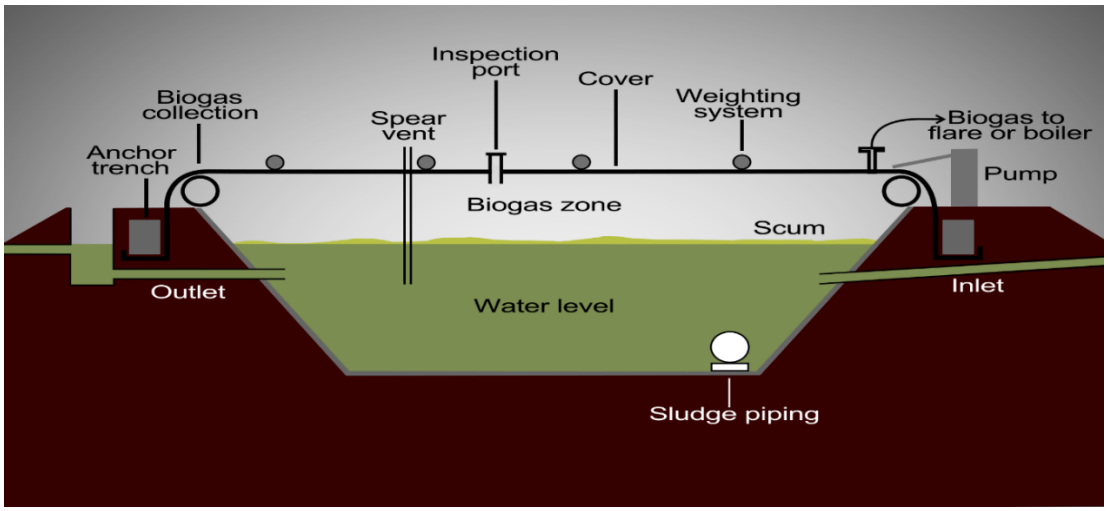

Figure 2: Cross section of a CAL

A biogas train typically consists of:

- A biogas pipeline to convey biogas from the CAL cover to the flare. It may be buried, or above ground.
- A knockout pot which is generally a stainless-steel vessel situated at the lowest point of the biogas pipeline to collect water condensing from the water-saturated biogas as it cools. The water can be safely drained at this point. This protects the downstream blower and instruments from damage
- A flow control valve, typically a PLC system, that controls biogas flow to the flare through the automated flow control valve. In many cases, the valve is controlled according to the pressure under the CAL cover permitting the flare to operate at a number of biogas flow settings.

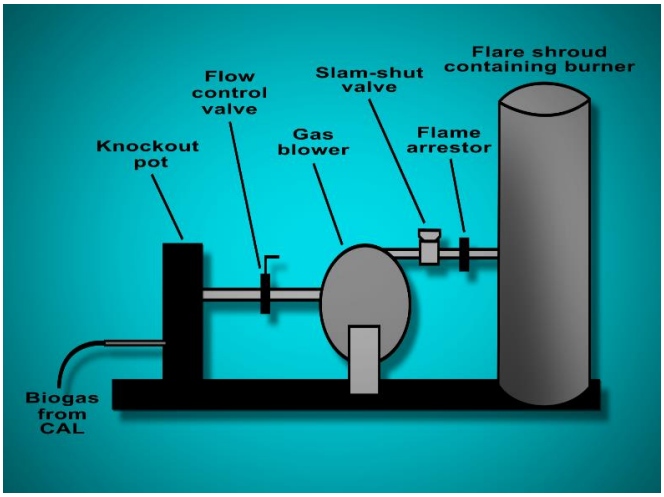

Figure 3: Typical layout of a biogas delivery system and flare

- A gas blower that provides positive pressure to convey biogas to the flare for incineration.
- A slam shut valve which is a fast acting valve system which shuts off the biogas supply in the event that the flare is not functioning or losing flame.
- A flame arrestor which is a safety device that prevents a flame from running back through the biogas supply line.
- A flare which incinerates the biogas safely.
- A priming system which usually uses LPG gas to feed the flare primer in case flare reignition is needed.

Table 2: There are two main types of flares:

	
Fully enclosed flare which controls the air supply to the biogas burner to ensure a hot flame for maximum odour and methane destruction. The flare is completely enclosed in a refractory shield. Image: JBS, Dinmore	Candlestick flare which is a vertical biogas tube with burner on top. The air supply is unlimited. This type of flare may have a metal shroud around the burner. This flare is less sensitive to biogas supply but can generate a cooler flame associated with less complete odour and methane destruction. Image: NB Foods, Oakey

The train may have a number of additional elements to condition the gas. These include:

- A stripping tower to remove or strip hydrogen sulphide which is corrosive to pipes and motors. This is generally required when biogas is used in boilers or cogeneration plants.
- Equipment for dehumidification. Water in saturated biogas is undesirable for cogeneration engines and is often chilled so excess moisture can be condensed and removed.

Stripping tower and dehumidifier
Image: NB Foods, Oakey

Biogas properties

Biogas generated by CALs is mainly a mixture of methane (55 – 75% v/v) and carbon dioxide. Minor traces of other gases such as hydrogen sulphide (H_2S) and volatile organic compounds (VOC) are usually present and may give the biogas an unpleasant odour and corrosive properties. The biogas is typically saturated with water vapour due to the confined, humid and often warm nature of the CAL.

Table3: Properties of biogas from CALs treating meat processing waste water

Property	Gas component responsible	Comment
Flammability	methane	Methane burns in air between the composition limits of 5 – 15% by volume. Outside of this limit it is not flammable.
Ignition temperature	methane	595°C. Methane requires very hot temperature for ignition.
Dustiness	Dust	Biogas contains negligible dust which might enhance its explosive properties.
Odour	hydrogen sulphide, VOCs	Biogas from meat plants is usually contaminated with H_2S making it offensive in odour (rotten eggs). Note methane is odourless.
Density	methane	Lighter than air. Biogas dissipates rapidly.
Toxicity	hydrogen sulphide, carbon dioxide	H_2S is toxic above 350 ppm and lethal at levels of 800 – 1,000 ppm. This level of H_2S is common in meat processing biogas. CO_2 causes suffocation.
Global warming potential	methane	Methane has a GWP of 21 times CO_2. Biogas methane is a major contributor to a facility's Scope 1 emissions.

Legislative and regulatory requirements

Odour and other emission requirements

Direct regulatory requirements concerning odour emissions will be stated in the facility's environmental protection licence, permit or approval which is issued by State Government. The same document will also indicate whether there are other compliance issues with flare operation such as light or noise emissions.

Climate change impacts

Biogas contains high quantities of methane which has a global warming potential 21 times that of CO_2. Emissions associated with methane and N_2O from CALs and anaerobic ponds must be reported under the *National Greenhouse and Energy Reporting Scheme (NGERS) Act 2007* for facilities or corporations which trigger the appropriate thresholds.

A major advantage of CAL technology is that the captured biogas is flared into the atmosphere or combusted for on-site energy generation, which reduces emissions by over 97%.

Flare burning methane
Image: NB Foods, Oakey

Gas equipment manufacture and operation requirements

There are stringent regulatory requirements in regards to gas equipment manufacture, installation and operation which include pipelines and all components downstream of the CAL and to the flare.

The safety of gas appliances is regulated by each State and Territory. A reasonably recent summary of this is given in the Rural Industries Research and Development Corporation (RIRDC) publication Assessment of Australian Biogas Flaring Standards (2008).

Supervisors and operators should be aware of the potential risks associated with biogas and follow appropriately designed protocols to minimise hazards.

Operator Responsibilities

Recommended day-to-day operator responsibilities include:

Inspections

- ☐ Observe all posted safety signs and protocols. Become familiar with the location of safety equipment such as fire extinguishers, emergency shutdown points, etc.
- ☐ Ensure monitoring instruments, such as biogas flowmeter, methane and/or oxygen analyser and pressure detection devices are operating properly. The high moisture content and corrosiveness of the biogas can cause problems with instrumentation. Where instruments become unserviceable, seek maintenance support quickly.
- ☐ Inspect the biogas delivery lines, especially where they connect to the CAL and major equipment items and check for leaks regularly. Notify maintenance if found. Note that air leaks into the biogas piping is as much of a concern as methane leaks out. Generally, it is recommended that the oxygen content of biogas is less than 4% of the volume.
- ☐ Ensure that the flare and blower are operating satisfactorily. If the flare alarms out constantly and for long periods, seek urgent assistance as biogas can rapidly accumulate under the CAL cover, causing it to inflate and begin emergency venting. In windy places, this can expose the CAL cover to high mechanical stresses with the risk of severe damage.
- ☐ Check at least weekly and notify maintenance of unusual blower vibration or temperature
- ☐ Drain the knockout pot (if a manual fitting is supplied) at least weekly and more often if necessary. Look for evidence of unusual drainage water, for example, water containing foam or mousse-like contents. This may indicate bacterial contamination of the biogas system.
- ☐ Regularly check the pilot gas fuel is sufficient for flare operation
- ☐ Regularly check flare operation e.g. daily. The flame should be colourless and odourless.
- ☐ Ensure upstream treatment processes are inspected several times a day to ensure everything is operating properly.

Monitoring

- ☐ Most monitoring is performed on-line and typically a biogas capture system should be fitted with:
  - biogas flow meter
  - methane and/or oxygen analyser
  - CAL cover pressure transmitter
  - various system temperature and pressure alarms.

  This information is generally logged to the facility supervisory control and data acquisition (SCADA) system for reporting and monitoring.
- ☐ A log should be maintained noting any unusual aspects of the system such as CAL cover inflation, etc.

Supervisor and management responsibilities

The primary responsibilities of the supervisor should be to ensure that:

- ☐ All safety protocols associated with the CAL and biogas capture system are clearly laid out in work instructions and standard operating procedures.
- ☐ The operator is competent in following them.
- ☐ Necessary personal protection and other safety equipment is available.
- ☐ The operator is aware of hazards in operating the biogas capture system i.e. risks of working in high temperatures, suffocation or poisoning (from biogas components), fire (methane) and the typical remoteness from the plant if something goes wrong and help is needed.

Other main responsibilities of management are as follows:

- ☐ Ensure that appropriate investment and maintenance support is provided. As stated above, in the event of biogas system failure, biogas will accumulate rapidly under the CAL cover with risks of mechanical damage to the cover.
- ☐ Regularly (preferably weekly) check biogas production and methane content. This is the most rapid and reliable means of assessing the health of the CAL. If the facility triggers the NGERS reporting threshold, good and consistent records will be needed regarding biogas volumes processed through the flare to satisfy annual NGERS reporting requirements.
- ☐ Ensure regular long-term checks and maintenance are performed on the elements of the biogas capture system according to the manufacturer's instructions.
- ☐ Liaise and report (as needed) to appropriate State regulatory authorities (e.g. Environment Protection Authority (EPA) and/or other) regarding the biogas capture system.

These fact sheets have been prepared by The Ecoefficiency Group Pty Ltd in association with Johns Environmental in 2017.