Farm Production & Practice

Ministry of Agriculture and Fisheries

Energy
Biogas Utilisation

Methane Produced by Anaerobic Digesters

Other index entry: anaerobic digesters.

Before considering the installation of an anaerobic digester, a final use for the biogas produced must receive careful consideration. Methane can be used for heating or as a fuel for internal combustion engines.

AgLink FPP 375 describes the production of biogas using an anaerobic digester. The following text outlines the properties of methane, processing, safety, storage, utilisation, and economics.

Biogas Properties

Biogas is a mixture of 50—70% methane and 50—30% carbon dioxide, with trace impurities of sulphide gases. Table 1 shows the calorific value (heating value) of methane in comparison with various other fuels.

TABLE 1: COMPARISON OF CALORIFIC VALUE OF METHANE WITH OTHER FUELS

Fuel	*Calorific value**
Biogas (65% CH_4)	23 MJ per cubic metre
Methane (CH_4)	35 MJ per cubic metre
Super petrol	33 MJ per litre
Diesel	36 MJ per litre
Coal	20—29 MJ per kg
Natural gas	42 MJ per cubic metre
Electricity	3.6 MJ per kW hour
Wood	14 MJ per kg
Town gas	18 MJ per cubic metre
LPG	44 MJ per kg

* Lower calorific value (LCV)

Processing

Biogas as produced by a digester contains hydrogen sulphide, which is highly corrosive and in nearly all situations should be removed. Its concentration will depend on the feedstock and can vary from 0.06% to 5%.

The simplest method of removing hydrogen sulphide is to pass the gas through a drum containing iron turnings. Periodically these need to be exposed to air to regenerate. Larger units sometimes use wood shavings soaked in iron sulphate, bubbling the gas through copper sulphate solution or spent oxide.

High moisture levels in the gas can be a problem. Removal of moisture is achieved by cooling the gas and removing the condensate through a trap.

Especially when biogas is used as a vehicle fuel, it is essential that the carbon dioxide is removed or at least reduced. Carbon dioxide is non-combustible and by its removal, the energy density of biogas will be improved considerably. Also if the methane/carbon dioxide ratio for the biogas is not constant, this will affect vehicle performance.

The simplest methods of removing carbon dioxide (called scrubbing) are:

Dissolving carbon dioxide in water under pressure.
- Bubbling biogas through caustic chemicals (e.g. lime water).

Safety

Air/biogas mixtures can be explosive. Certain precautions must be taken:

- Installation of flame traps in all gas pipelines — either asbestos or metal gauze in the pipeline, bubbling the gas through water, or pressure-sensitive one-way valves can be used for this purpose.
- Good ventilation wherever the gas is stored or used.
- Pressure relief valves, vented well away from the working area.
- Purging of the digester and pipelines of gas before conducting any repairs.
- Before using the gas, ensuring that all air is removed from the system.
- Burning off excess gas at a safe distance from the plant.

Storage

Unless gas demand exactly matches gas production, some form of gas storage is required. Low-pressure storage systems are the most common, but if the gas is also used as a vehicle fuel, some storage can be provided at high pressures.

At low pressures (100 to 150 mm of water gauge is common) gasometers and butyl rubber bags can be used. However, to store significant quantities of energy, enormous volumes are needed. To contain the same energy as a 200 litre drum of petrol, a low-pressure storage system will need a volume of about 300 cubic metres (equivalent to an average-sized house).

High pressure systems use a three- or four-stage compressor to compress the gas to pressures of approximately 25 MPa (3500 psi) and contain it in high pressure cylinders. Even at these high pressures methane still has only one-sixth of the energy density of liquid fuels.

Present costs are approximately $70 per cubic metre for low pressure and $50 per cubic metre for high pressure storage.

Because of the difficulties with both low and high pressure storage, it is vitally important to match the production and demand for gas as closely as possible. Methane production from the digester can be varied according to demand simply by altering the feedstock loading rate into the digester. Response time is generally 1—2 days. Unfortunately, any reduction in utilising the digester's full production capabilities will decrease the returns from it and thus increase the cost per cubic metre of biogas.

Demand for the gas will depend on the intended use. Uses such as crop drying, glasshouse heating and tractors often have high seasonal or high daily requirements and are difficult to match with supply from the digester. Thus to keep storage to a minimum, every effort should be made

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to use biogas in applications where demand is relatively constant.

Utilisation

Heating: Biogas can be used as a heating fuel for a variety of purposes in exactly the same manner as natural gas, LPG, or town gas. Burners designed for these gases can be used without modification for biogas, but for efficient combustion the size of the burner jets should be modified to provide the correct gas/air ratio and mixture velocity.

For complete burning of methane, the gas/air volume ratio should be about 1:9.6. Mixture velocity depends on the size of the jet and the pressure of the gas.

Biogas can be used domestically for hot water heating, home cooking and heating like other gas. Consumption per household for these functions is approximately 1000 cu m of methane annually.

Biogas could replace any of the fuels at present used for crop drying. Because this use is often seasonal and the gas consumption relatively high, carefully consider the effect this will have on storage volumes required, etc. Fortunately, many crops do not need to be dried immediately after harvest, and this property can be used to lengthen the drying process.

Similar problems of seasonal use exist in glasshouse heating. Biogas use, however, besides providing heating, can also offer carbon dioxide enrichment, boosting yields of crops like tomatoes. Piggeries, poultry houses or other animal houses could also use biogas as a source of heating.

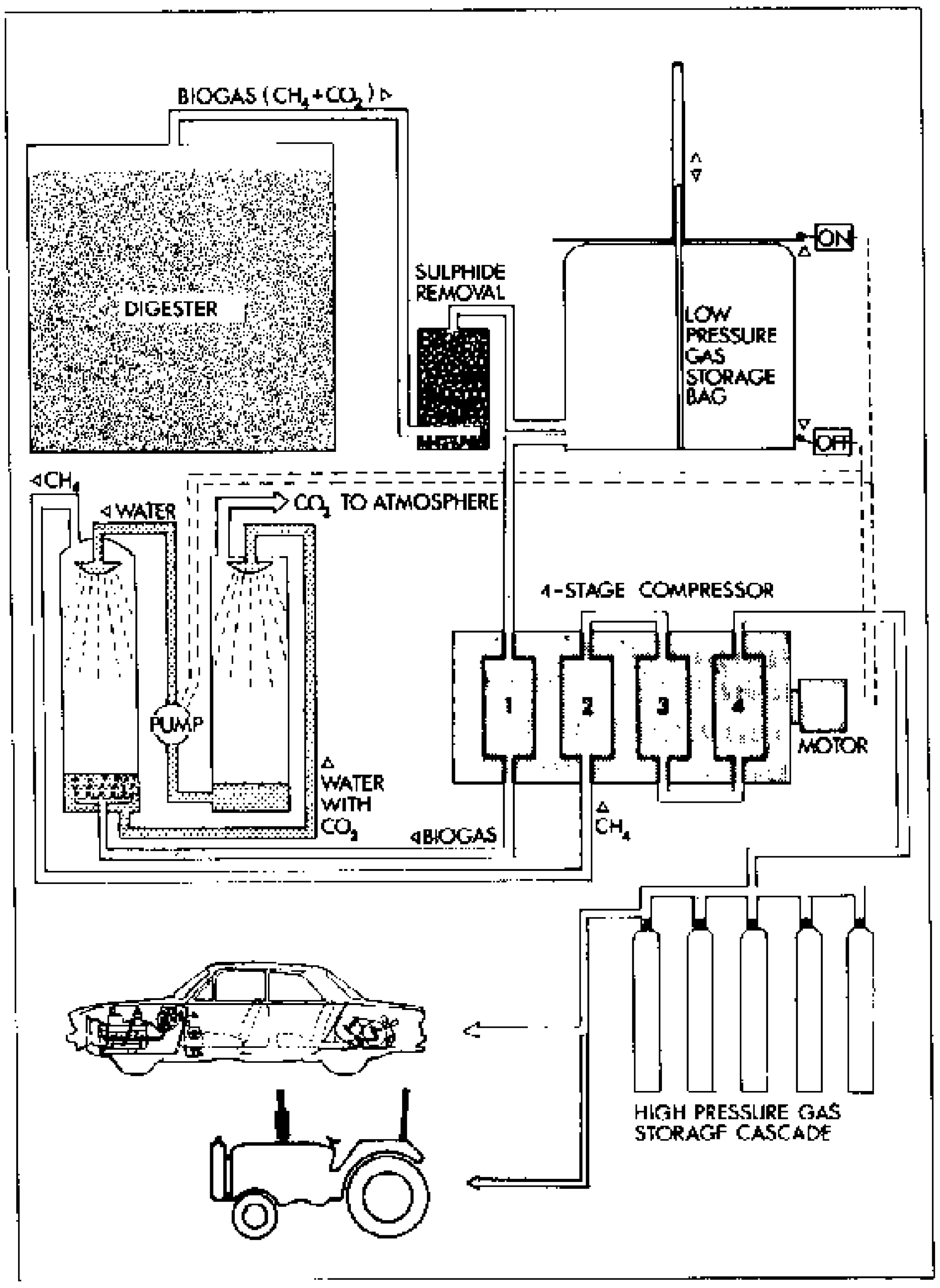

Fig. 1: Schematic illustration of the production and use of biogas in vehicles.

Vehicle fuel: Methane is a good engine fuel. Conversion kits are available in New Zealand to convert petrol engines for CNG, and these can also be used for methane. Diesel engines are not so easily converted, but several conversion kits are now available. The major disadvantage of methane as a vehicle fuel is the limited range possible without increasing the weight of the vehicle excessively. (See AgLink FPP 424 for further details on engine conversions, etc.)

For use in vehicles, the methane is compressed in either a three- or four-stage compressor to 25 MPa (3500 psi) and stored in a group of high pressure storage cylinders (cascade). This cascade is necessary to facilitate quick refuelling of the vehicle's storage cylinders.

The number of cylinders in the cascade will depend on the size of digester and the number of cylinders fitted to each vehicle. For a 45 cu. m digester at least four 9.2 cu. m cylinders would be necessary. Similarly, the hourly capacity of the compressor must exceed the hourly methane production from the digester if vehicle fuelling is the principal gas use.

Stationary internal combustion engines: The use of biogas for stationary engines has the advantage of not necessarily requiring compressed storage of the gas or the removal of carbon dioxide. Also the waste heat from a stationary engine can be recovered for digester heating, thereby increasing overall efficiency.

Stationary diesel engines driving a constant load at constant speed can be easily converted to run on up to 90% biogas. Some diesel is still required for ignition however. These dual-fuel (diesel/biogas) engines are often used by sewage treatment works for pumping and electricity generation.

Possible uses for stationary engines are electricity generation, pumping, driving fans, etc. Electricity generating plants powered by biogas are available in New Zealand.

Economics

The cost and use of biogas depends on the digester size, cost and type of feed material, climate, use, capital cost of the system, and how closely the supply and demand are matched. With all these variables it is difficult to generalise on an actual cost.

Example: Where a group of farmers install a 183 cu. m (40 000 gallon) digester system for their own use in 20 vehicles, the cost of the methane produced and utilised might be about 45 cents/cu. m, equivalent to 42 cents per litre of petrol. This cost assumes a $400/ha gross margin return for crop production, capital cost of $110,000 for digester system, compression, storage and vehicle conversions, annual production of 98 000 cu. m methane (approximately equivalent to 105 000 litres of petrol), and includes annual capital and interest payments over a 15-year period, operating and maintenance costs and crop production and storage costs. It does not include allowance for the tax write-offs allowable, improvements in fuel economy for vehicles running on methane in place of petrol or the reduced vehicle maintenance costs that are likely.

In the above example, if the gross margin return is neglected the cost per cubic metre is reduced to 35 cents. Similarly, if animal or farm wastes of no cost are used for feed material, the cost per cubic metre of the biogas might be 25—60 cents, depending on the type of material. Alternatively, if the biogas is used for purposes other than as a vehicle fuel, cost per cubic metre is about 35 cents. For vehicles used on the road, a road tax may also be payable as is now the case with CNG and LPG.

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