Biogas use in developing countries and the UK

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What is Biogas?

Biogas is a combustible mixture of gasses, typically produced through a process known as *anaerobic digestion* of biomass.
Anaerobic digestion can be seen as "composting without air": Under normal conditions, such as in your compost bin, aerobic (oxygen breathing) organisms break down biodegradable organic materials into simpler forms of matter, producing carbon dioxide (CO_2) in the process. But in anaerobic digestion, biomass is decomposed under exclusion of air. In the absence of oxygen, a different type of (anaerobic) microorganisms breaks down the biomass, producing methane (CH_4), a combustible gas.
In practice, biogas produced through anaerobic digestion is usually a mixture of methane (45-85%) and carbon dioxide (15-45%) with small amounts of other gasses. It can be purified to achieve higher methane concentrations.

The energy value of biogas depends on the methane concentration. Pure methane gas has an energy value of around 10 kWh/m^3, biogas with a methane concentration of 60% can provide around 6 kWh/m^3.

What can biomass be made from?

In principle, most types of biomass can be used as feedstock for biogas production. Manure from many types of domestic animals, waste from kitchens, gardens, agriculture and slaughter-houses, and even human excreta have all been used for anaerobic digestion.
Gas yields will depend on the feedstock used. One tonne of cow manure produces around 36 m^3 biogas, whereas figures from a demonstration biogas plant in Ludlow, Shropshire, suggest that one tonne of UK household kitchen waste produces ca. 140 m^3.
Another factor which strongly influences biogas production is process temperature. Temperatures around 35°C are ideal for biogas production. Even at 20°C, gas yields will be significantly lower than at the optimal temperature.

Is biogas the same as "Natural Gas"?

Biogas should not be confused with what is known as "natural gas", a gaseous *fossil fuel* consisting primarily of methane. Chemically, purified biogas and some types of natural gas are very similar and can be used with the same appliances. However, the important difference is that natural gas is a fossil fuel which causes global warming, whereas biogas can be a sustainable, carbon-neutral source of energy.

Biogas and climate change

Carbon dioxide released by burning fossil fuels is the primary cause of global warming.
Burning methane, for example for cooking or to run a generator, produces carbon dioxide and water. However, all the carbon contained in biogas (in the form of carbon dioxide and methane) has previously been absorbed from the atmosphere by the plants which produced the feedstock. Hence burning biogas will only release as much carbon dioxide into the air as the plants have taken out of it, and as long as the biomass is allowed to regenerate, biogas is a carbon-neutral source of energy.

However, methane itself s a potent greenhouse gas, many times more powerful than carbon dioxide in causing climate change. Therefore it is important that all gas is burnt and that there is no leakage during the production and distribution of biogas.

Aren't biofuels bad?

Biogas is a biofuel in the sense that it is a fuel derived from (non-fossil) biological material. However, the public debate around biofuels is mostly concerned with liquid fuels such as vegetable oil, biodiesel and ethanol. These liquid fuels are often produced from plants specifically grown for this purpose, e.g. corn, rapeseed or coconut palms.
Growing plants specifically for the purpose of fuel production can be problematic as it often requires a lot of energy (in the form of fertilizers), competes with food production and, as in the case of palm oil, can lead to the destruction of natural habitats.

As long as biogas is produced from waste products no additional energy or land is required for the production of biomass feedstock. Energy is, of course, required for transporting of biomass to a biogas plant.

What about the slurry?

Only a small proportion of the total mass of the feedstock is converted into biogas. The remainder is converted into nutrient-rich slurry which can be used as a biofertilizer. The anaerobic digestion process eradicates most pathogens. Studies show that counts of fecal coliform bacteria can be reduced by 99.9%.

Biogas use in developing countries

Anaerobic digestion has been very successful in developing countries with warmer climates. India and China have promoted biogas for more than 50 years, and today there are several million installed digesters.

A typical biogas digester would consist of a simple brick dome structure which has a volume of 1-3 m^3 volume and is partially or fully underground, as well as an inlet for feedstock and outlets for slurry and gas. The gas is piped to the kitchen where it is used for cooking on a gas stove.
Plants can be constructed by local builders using locally available materials. For a family in India it costs around £200 to build a digester which uses the manure produced by 2-6 cows to produce enough gas for most or all cooking needs.

Where biogas replaces firewood as a fuel for cooking, this technology helps to reduce deforestation. Also, as biogas burns much cleaner than traditional wood stoves, it helps to reduce eye- and respiratory diseases caused by smoke in unventilated houses (the WHO estimates that Exposure to indoor air pollution may be responsible for nearly 2 million excess deaths in developing countries).

Biogas use in the UK

The cheap and simple household-scale biogas digester concept used in India and China is not suitable for the UK for two reasons:
First, these household-scale digesters are designed for around 10 to100 kg of biomass feedstock per day. A typical UK household without any farm animals produces much less, whereas an industrial farm produces much more.
Second, the climatic conditions in the UK require heating and/or insulation, leading to more complex and expensive digester designs.

As a result, in the UK biogas plants are typically larger, with digester volumes of 500 – 5000m^3 which requires several thousand tons of biomass input per year. At this scale, a digester will often produce more biogas than a single farm requires for cooking or heating purposes. Usually, the biogas is burnt in the generator of a combined heat and power (CHP) unit which produces heat and electricity.

In South Shropshire, a digester uses 5,000 tonnes of household food waste per year to run a 195kW CHP. A proportion of the electricity (15%) is needed to run the plant. The rest – enough to supply a few hundred households – is sold to the national grid. Of the heat, 40% is needed to heat the digester. The excess is currently wasted but there are plans to install a local district heating scheme.

A problem with the use of biogas for CHP generation is that biogas plants are not normally located in densely populated areas. This makes piping of heat for district heating less viable.
In Germany, where government subsidies have lead to the creation of around 4,000 farm-scale biogas plants, and in the USA, biogas farms have started to export purified biogas into the national gas grid.

Further Information

Biogas in developing countries:

Ashden Awards
The website for the Ashden Awards for Sustainable Energy lists several biogas projects in Africa and Asia and provides videos as well as case study documents
www.ashdenawards.org/biogas

Practical Action
Practical Action is a UK-based development charity. They promote biogas technology in South Asia.
Tel: 01926 634400
www.practicalaction.org/?id=biogas

Biogas in the UK:

Greenfinch Ltd (now Biogen)
UK company which operates the household waste biogas plant in South Shropshire.
Tel: 01584 878131
www.greenfinch.co.uk
NOTE: Company details are provided for your information, not as an endorsement by CAT

CAT publications:

"Running a Biogas Program: a Handbook"
Covers everything from design and use of biogas plants for both domestic and community use to the likely social and economic effects plus advice on management.
Fulford (1988), 188 pages, £17.95

"Chinese Biogas Manual"
Based on detailed descriptions and including many diagrams and pictures, this manual shows how to build a biogas pit and how the designs can be adapted for construction in different soils, from sandstone to sheer rock.
van Buren (1979), 136 pages. £10.95