Anaerobic Digestion (AD): the potential for horticulture

This feature on anaerobic digestion has come together as much through serendipity as planning. Garden Organic's Francis Rayns attended a workshop in Cirencester, which we thought was worth reporting on (below); and Richard Northridge of Cwm Harry Trust contacted us to ask if any of our members might be interested in AD. Sam Eglington then remembered a conversation at the 2010 producer conference that led to an article on Methanogen Ltd and their biogastronome range. It also continues on from Jenny Griggs letter in OG14, commenting on the possibility of processing green manures through a digester as an alternative to simply mowing and leaving them to rot. The principal obstacle to using waste heat for greenhouses is that the heat is required in winter and the green manures cut in summer; but this is easily overcome by ensiling. The greatest challenge may be the efficiency of the heating systems, not the digester. The gas could also be captured for flame weeding. AD's great virtue is that is enables energy to be extracted from organic matter without destroying that organic matter. A renewable energy source captured in a renewable way, no doubt has an important place in future production.

From small to large: Using AD to recycle nutrients and create energy

The use of anaerobic digestion in horticulture in the UK is still largely in its infancy. Countries such as India and China have large numbers of small family digesters which are fed with food waste, humanure and the slurry/manure from a handful of stock such as cattle. The resulting effluent, digestate, is spread back to land to grow a wide variety of local foodstuffs. In these countries, the biogas from the AD process is generally used for cooking and possibly even gas lighting.

In the UK, many AD plants separate the digestate into a liquid and a fibre. For years, the few UK farmers who own digesters have offered digestate to gardeners who have grown award-winning fruit, flowers and vegetables, finding it to be a wonderful product for many reasons. These include:

- The nitrogen in the digestate is more readily available to plants
- Digestate is a stable product and is less likely to cause pollution than the 'waste' it was created from
- Digestate contains trace elements which are valuable to plant nutrition
- The fibrous portion adds to soil structure, helping to hold moisture and providing slower release elements to plants

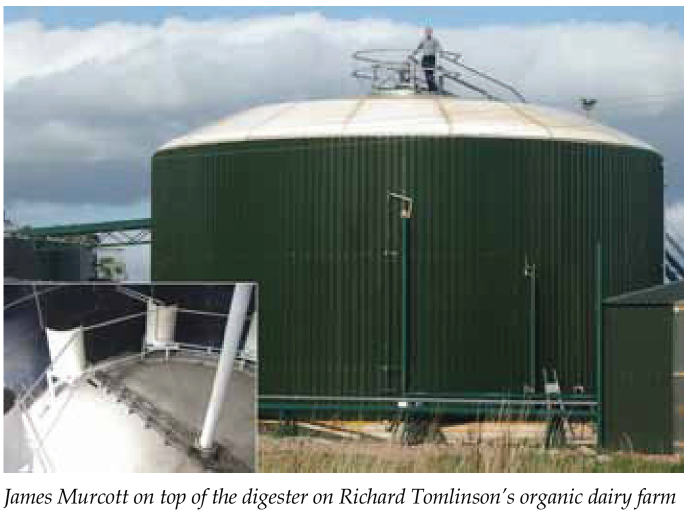


Photo: Fre-energy

James Murcott on top of the digester on Richard Tomlinson's organic dairy farm

James Murcott of Methanogen UK Ltd has been building successful farm-scale digesters for over 30 years and is passionate in his belief that digesters based on farms and smallholdings are the best way to return non-woody organic materials back to land. "Food comes from the land and the nutrients should be returned to the land. With AD, all the so-called 'waste' in the food chain, from producer to processor to consumer, can be utilised to create energy, as well as returning nutrients to land in a readily available form, thus creating a truly organic biological cycle", he says.

Over the years, James has designed and engineered a number of innovations in digester technology and his products are renowned for their simplicity to operate, low running costs and longevity, with systems running for 20 years and more. His systems vary from the usual above-ground tank structures, to partially or fully underground digesters. He has even built a digester inside a stone building and under a cowshed. His latest innovation, licensed to Fre-Energy, is an automatic de-gritting system which means that gritty feedstocks, such as slurries from cows bedded on sand, chicken muck from layers or unwashed sugar beet can be digested.

When James found himself living off-grid, he decided to design a micro-scale AD system which could be fed with garden waste, humanure and food waste – not an easy challenge! Thus, the 'Biogastronomy' range of digesters was born, ranging in size from 0.2m3 to 20m3. These digesters have integrated shredding and can be run using 12V or 240V and heated from dual sources, such as 240V electric and thermal solar. During the past two years, a number of units have gone into operation and they have generated a great deal of interest. Development is continuing on these digesters and their ancillaries, in order to continue the tradition of creating digester systems that are simple, robust and cost effective to operate.

In addition to reducing pollution and recycling nutrients, AD also produces biogas, a renewable energy fuel which attracts government incentives. The amount of gas produced depends

2m³ biogastronome running on solar PV in process of being installed.

upon the type and quantity of the feedstock. Different feedstocks require different retention times in the digester. For example, if a feedstock has a retention time of 20 days and is fed into a 60m3 digester, 3m3 (approximately three tonnes) of feedstock can be fed into the digester on a daily basis. As a rough rule of thumb, fatty or sugary feedstocks produce more biogas per kg, with feedstocks such as slurries producing much less. However, it is necessary to co-digest these high-strength feedstocks with a slurry/manure, since these tend to 'buffer' the digester, providing stability to the process, as well as vital trace elements and bacteria. A chart of typical biogas yields for a variety of feedstocks is shown above right.

The biogas (primarily consisting of about 60% methane and 40% carbon dioxide) can be burned directly in a boiler, Aga, Rayburn, gas burner, or used to fuel a Combined Heat and Power (CHP) plant in order to create electricity. CHP waste heat can be used to heat buildings, polytunnels, water, and so on. The gas can also be upgraded and injected into the gas mains or used as a vehicle fuel. One m3 biogas is approximately equal to 0.6l fuel (such as diesel, petrol or heating oil).

Typical costs of various types of digester are shown opposite but these can vary considerably depending upon the site, the feedstock pre-processing and a number of other factors. Further detailed case studies can be obtained from a recent Royal Agricultural Society of England report.

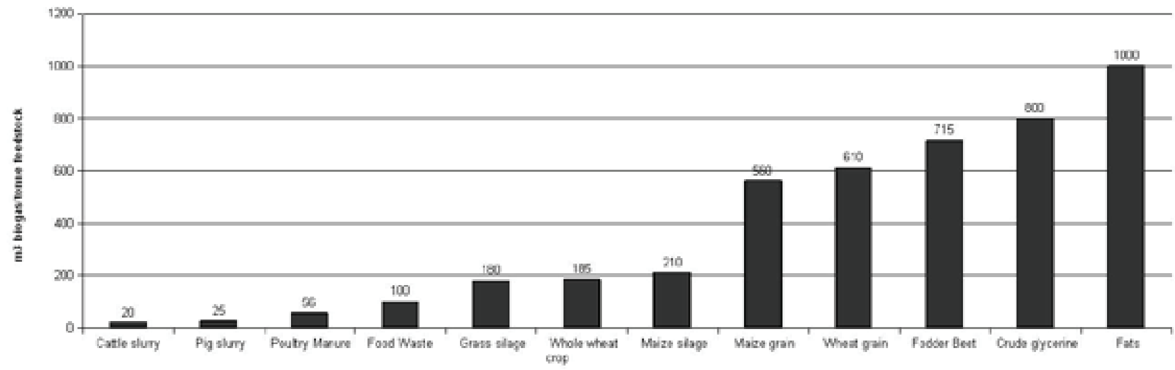
Digester size	Typical feedstock	Digester type	Approx. cost
2m3	Grass mowings Garden waste Food waste	Biogastronome Mechanically stirred Mains powered Direct gas use – burner/boiler	£7000
20m3	Grass silage from approx 2 acres Garden waste	Biogastronome Mechanically stirred Mains powered Gas runs Rayburn/Aga year-round	£36,000
150m3	Cattle slurry Grass silage	Methanogen gas mixing system Insulated steel tank, fixed roof Auger feed system Gas used in micro-CHP* or direct use	£150,000
500m3	Grass silage Chicken muck	Self build insulated concrete tank Methanogen gas mixing system Auger feed system Gas used in CHP* (usually too much gas for direct gas use)	£200,000
1100m3	Cattle Slurry Chicken muck	De-gritting system Insulated steel tank, fixed roof Multi-purpose feed wagon system Gas used in CHP*	£600,000

**CHP not included in price, nor is cost of connection to the electricity grid. Note that digesters with CHP must run all year round and create high quality gas in order to continuously create electricity.*

Methanogen believe that AD will become increasingly important in agriculture as a means of reducing air and water pollution, reducing the cost of fuel and fertiliser and treating a wide variety of organic materials so that they can be returned to the land from whence they came in a readily available form.

Angie Bywater

www.methanogen.co.uk www.biogastronomy.co.uk.

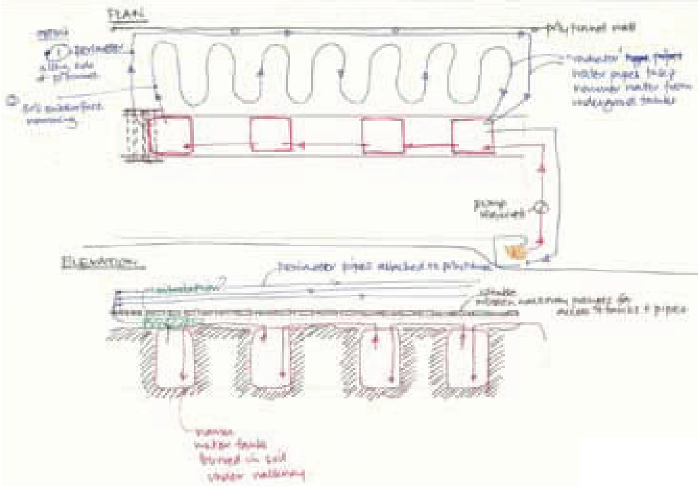


Micro AD

In the UK's rush to biogas, large scale AD plants have so far dominated both official and industry thinking. The view is that large systems are the only feasible option because of economic constraints, notwithstanding the level of investment, planning and long lead time required to build these plants. Furthermore, the market has been distorted by Government offering substantial grants to support capital expenditure. This has created a feeding frenzy, where large technology providers are bidding to build the biggest and best. This, in turn, has generated a view amongst the feedstock suppliers of "wait and see," where they are waiting for the gate fees to tumble to the point where the AD operators are vying with each other to buy feedstock, as happens in Germany. What's been overlooked is that Germany is about 25 years ahead of us and has 2,500 active AD plants whilst the UK has 54. All in all this has had the opposite effect of what was intended: it's making big AD almost unbankable as the contracts for feedstock supply aren't in place, with reluctance on the part of the local authorities to underpin those supplies with minimum tonnage clauses.

Not surprisingly, community composters think this trend in the UK's development of AD is nonsensical because it ignores the huge implications accompanying centralised plants: their ever demanding hunger for feedstock which will deter waste minimisation, something that source separation of food waste has been found to engender, as well as transporting dense, heavy material over long distances. Consequently, some members of the Community Composting Network (CCN) are having a go at small-scale AD ('mAD'), inspired by the fact that there are millions of small biogas plants all over the world, especially in "intermediate technology" societies like China and India, who apply the proximity principle.

System showing digester in the background with hot water boiler in the foreground.



Sketch plan for heating polytunnel

CCN's mAD project is governed by Open Source criteria; the project seeks to package community scale AD, thereby making the technology accessible and adoptable by all manner of communities across the UK. Its first test build, supported with a grant from the Big Lottery's Local Food Fund, is operating at Cyrenians, a social enterprise in Newcastle, which runs a hostel for homeless people linked to a horticulture project, comprising an ornamental garden with polytunnels for salad and vegetable cropping. The wet $1m^3$ digester is designed and built by James Murcott. The parameters of the test build include compliance with bio-security regulations, so apart from pre-treatment maceration, the feedstock comprising food from the canteen and soft garden waste material is also pasteurised at 70°C for an hour. The biogas is used in a boiler which pasteurises as well as heats the polytunnel in which the digester is located. The hardware has been put together for about £3500; however this excludes purchase of the digester itself, but includes equipment for pasteurisation, heating, gas storage, burning, containment and insulation. There could be much cheaper DIY possibilities, which the mAD project is currently working on. There may also be no need to pasteurise the material if it comes from and is used exclusively on site, which would save capital costs and reduce parasitic energy loading, allowing more gas to be used to heat ground. The digestate is treated as fertiliser and a source of valuable nutrients for the horticultural side of Cyrenians. The CCN will be running a training day in the summer at the site, for community groups interested in participating in the development of the systems.

Biogas and digestate could become key ingredients in building viable local food economies, a goal community-based organics recyclers have been aiming at for many years. From all accounts, food security is rising up the political agenda at an encouraging speed. At the present time, Britain imports nearly 40% of its food, most of its energy and nearly all of its fibre. So if it came to it, could we feed ourselves? Appropriately scaled AD could be a vital part of a jigsaw puzzle of what is also fast emerging – an alternative model of life-support systems based on local, dispersed, low-energy intermediate technological solutions at the micro and midi scales.

Richard Northridge

Using heat from biodigesters to heat tunnels

In March 2011 an event was held at the Royal Agricultural College in Cirencester to discuss the potential for using surplus heat from biodigesters in horticultural production. Anaerobic digestion (AD) is a method for processing a variety of organic materials in the absence of oxygen (in contrast to composting). It is usually done at an elevated temperature and produces methane gas plus 'digestate' – a nutrient rich material which can be used as a soil improver.

Anaerobic digestion produces methane gas, which on a large scale is usually burnt on site to drive a generator to feed electricity into the national grid. This also produces heat; some of this can be used to keep the digester at an optimal working temperature; however much is more difficult to utilise and is often wasted. Some digesters have been deliberately sited near to hospitals, for example, where the heat can be piped away to warm radiators; but an obvious option is to use it in horticultural production. The meeting in Cirencester presented the results of a project instigated by South West Food and Drink as part of a more general initiative to support the development of sustainable food chains in the South West of England. This took a case study approach to evaluate the potential for Kemble Farms in Gloucestershire to utilise heat from their existing AD plant. This was built in the last five years to process cattle slurry, maize silage and glycerol. It was calculated that there was sufficient surplus heat to fuel a protected cropping enterprise of about 1ha in extent. Aubergines, for supply to supermarkets, were modelled in the calculations; but there would obviously be potential to grow other crops. It was estimated that the considerable investment needed would be repaid within four years; although this was dependant on obtaining the expected aubergine yields and prices! The system envisaged was conventional with hydroponic growing – this certainly did not make the best use of the resource of the digestate as a crop nutrient/soil improver.

The acceptability of such a large-scale AD and protected cropping facility within an organic system can certainly be questioned. However, there is potential for organic farmers and growers to use AD for the more effective processing of farm and other wastes. One possibility would be the better utilisation of green manure foliage that is currently cut and mulched – if digested it will produce biogas and can subsequently be returned to the soil without loss of any nutrients. One issue is that there is currently a lack of commercially available small to medium digestion systems (although work is being done in this area). There is scope for DIY approaches, but the management time needed should not be underestimated and costs and benefits must be carefully evaluated.

Francis Rayns, Garden Organic