September 2007

Friends of the Earth

Briefing

Anaerobic digestion

Currently, much of our biodegradable waste such as food, garden waste, card and paper is sent to landfill, where it breaks down to release methane, a powerful greenhouse gas.

Anaerobic digestion (AD) is a treatment that composts this waste in the absence of oxygen, producing a biogas that can be used to generate electricity and heat.

Producing 100 per cent renewable energy from our biodegradable waste helps tackle climate change, instead of contributing to climate change through landfilling and incineration.

Friends of the Earth inspires solutions to environmental problems, which make life better for people.

Friends of the Earth is:

- **the UK's most influential national environmental campaigning organisation**
- **the most extensive environmental network in the world, with almost one million supporters across five continents and over 60 national organisations worldwide**
- **a unique network of campaigning local groups, working in over 200 communities throughout England, Wales and Northern Ireland**
- **dependent on individuals for over 90 per cent of its income.**

To join or make a donation call us on 0800 581 051

Friends of the Earth, 26-28 Underwood Street, London N1 7JQ
Tel: 020 7490 1555 Fax: 020 7490 0881 Email: info@foe.co.uk Website: www.foe.co.uk

Friends of the Earth Limited company number 1012357
♻ Printed on paper made from 100 per cent post-consumer waste

Introduction

Anaerobic Digestion (AD) is a biological process that happens naturally when bacteria breaks down organic matter in environments with little or no oxygen. It is effectively a controlled and enclosed version of the anaerobic breakdown of organic waste in landfill which releases methane.

Almost any organic material can be processed with AD, including waste paper and cardboard (which is of too low a grade to recycle, e.g. because of food contamination), grass clippings, leftover food, industrial effluents, sewage and animal waste.

Energy

AD produces a biogas made up of around 60 per cent methane and 40 per cent carbon dioxide (CO_2). This can be burnt to generate heat or electricity or can be used as a vehicle fuel. If used to generate electricity the biogas needs to be scrubbed. It can then power the AD process or be added to the national grid and heat for homes.

Digestate

As well as biogas, AD produces a solid and liquid residue called digestate which can be used as a soil conditioner to fertilise land. The amount of biogas and the quality of digestates obtained will vary according to the feedstock used. More gas will be produced if the feedstock is putrescible, which means it is more liable to decompose. Sewage and manure yield less biogas as the animal which produced it has already taken out some of the energy content.

Applications

In the UK, AD has until recently been limited to small on-farm digesters. However AD is widely used across Europe. Denmark has a number of farm co-operative AD plants which produce electricity and district heating for local villages, biogas plants have been built in Sweden to produce vehicle fuel for fleets of town buses and Germany and Austria have several thousand on-farm digesters treating mixtures of manure, energy crops and restaurant waste, with the biogas used to produce electricity.[1]

AD is also widespread in other parts of the world. India and Thailand have several thousand mostly small scale plants. In developing countries, simple home and farm-based AD systems offer the potential for cheap, low cost energy from biogas.

When treating municipal waste, AD can be used to process specific source separated waste streams such as separately collected food waste. The digestate will be uncontaminated so can be used as a soil improver. To minimise the impact our waste has on the climate, Friends of the Earth believes that compostable and recyclable material should be separated at source for treatment or reprocessing, using AD where suitable.

Mechanical biological treatment

AD can also be combined with mechanical sorting systems to process residual mixed municipal waste (mechanical biological treatment or MBT). After recyclable and compostable materials have been separated from the waste stream, MBT is the best way to treat the remaining waste in terms of the environment, and in particular climate change.[2] In Friends of

the Earth's view MBT should occur in small, localised treatment plants to minimise waste transport.

In an MBT facility, the waste goes through two processes, though the order can vary:

1. machinery is used to mechanically remove any remaining recyclable waste still left in the waste stream (e.g. metals, plastics, glass)
2. the waste is composted or anaerobically digested. This reduces the volume of waste and makes it biologically inactive so it can be landfilled without releasing methane.

If the residue is clean enough it can also be used for land reclamation on brownfield sites, landfill restoration and as a soil additive. Some councils may propose to burn the MBT residue as a 'Refuse Derived Fuel' or 'Solid Recovered Fuel' – Friends of the Earth does not support this. For more details see our briefing on MBT: http://www.foe.co.uk/resource/briefings/mchnical_biolo_treatmnt.pdf

Local authorities may see MBT as a substitute for source separating materials for recycling and composting, but this would be a mistake. Source separated collections to maximise removal of food waste, garden waste and recyclables should always take place before waste is treated with MBT.

More information on the benefits of collecting recyclables separately can be found in the briefing on recycling collections at http://www.foe.co.uk/resource/briefings/recycling_collections.pdf

Weekly food waste collections

At least 0.36 per cent of UK electricity generation could be generated by AD of source-separated household waste such as food waste.[2] Even more could be generated with non-household waste streams, such as food waste from restaurants, caféteria and retailers.

Weekly food collections also have a big impact on recycling rates. Bristol was the first city in the UK to offer weekly food waste collections to all residents. When it introduced the collections its recycling rate jumped from 18 per cent to 37 per cent in a year.

As well as cutting waste, increasing recycling and tackling climate change, weekly food collections also help to counter criticisms of fortnightly waste collections, which largely centre round kitchen waste. Removing food waste from bins reduces smells and vermin associated with fortnightly rubbish collections.

For more information on food waste collections, please see the briefing at http://www.foe.co.uk/resource/briefings/food_waste.pdf.

Garden waste

Although AD can process garden wastes, too much garden waste in the mix reduces the yield of biogas, as a substance called lignin which is found in woody materials does not break down without oxygen.

If the feedstock contains lots of woody waste and AD cannot break it down enough for it to be used as a soil conditioner, it can also be composted. In some plants (e.g. at Ypres in

Belgium – see case study on page 6), an AD plant operates alongside composting and the AD digestate is added into the composting process. AD can also complement composting systems by treating biodegradable waste that can't be processed through windrow composting (e.g. cooked kitchen waste and animal by-products).

Waste Strategy for England 2007

The new English Waste Strategy was published in May 2007. It strongly supports using AD to treat food waste, which it recommends collecting separately from households each week.[3] It recognises that "*AD has significant environmental benefits over other options for food waste*" and states "*the government wishes to encourage more consideration of the use of AD both by local authorities and businesses*".

The strategy is less positive about creating energy from waste through incineration. The emphasis on the benefits of AD is significant as it provides a lead to councils who had previously being influenced by the pro-incineration Waste Strategy 2000.

The English Waste Strategy 2007 is available at the following address:
http://www.defra.gov.uk/environment/waste/strategy

Climate change

At the moment in the UK, most of the food and garden waste separately collected by councils is composted. However, AD has the advantage of generating energy,[4] which reduces emissions of climate change gases by offsetting emissions from fossil fuelled power stations.[5] It therefore gives higher net carbon savings than composting.[6]

If just 5.5 million tonnes of food waste was treated by AD we could generate between 477 and 761 GWh of electricity each year – enough to meet the needs of up to 164,000 households.[7] Compared to composting the same amount of food waste, treating it with AD would save between 0.22 and 0.35 million tonnes of CO_2 equivalent, assuming the displaced source is gas-fired electricity generation. But at the moment we only AD 50,000 tonnes of food waste each year - 0.4 per cent of the UK's food waste.[6]

AD is a waste treatment that powers itself. Using AD to treat sewage waste reduces CO_2 emissions by 16 per cent compared to conventional sewage treatment techniques.[8] Using the soil improver also brings climate benefits through storing up some carbon in the soil and by displacing the use of mineral fertiliser, which requires significant energy input to produce.

The biogas from an AD plant can be burnt in a combined heat and power (CHP) plant, generating renewable-only heating. Such AD/CHP plants are well suited for use in distributed generation schemes, where power and heat are generated more locally than in our current electricity supply system. Plants can be small and low rise so may be situated in towns, reducing haulage distances and associated traffic pollutants. They are likely to be more acceptable to local communities than larger waste management facilities.

Other benefits

As well as being better for the climate, AD has other benefits over traditional waste management technologies. Plants can be small and low rise so may be situated in towns, reducing haulage distances and associated traffic pollutants. They are faster to build and to get planning permission for, as proposals are more acceptable to local residents than with other technologies. AD also produces less air and solid emissions than incineration, landfill and pyrolysis and gasification.[5]

How AD works

The material to be processed can be shredded to increase the surface area available to microbes in the digesters and hence increase the speed of digestion. The AD process takes place in an airtight container, known as a digester.

The first stage of AD is a chemical reaction called hydrolysis, where complex organic molecules are broken down into simple sugars, amino acids, and fatty acids with the addition of hydroxyl groups.

This is followed by three biological processes:

- acidogenesis - further broken down by acidogenic bacteria by into simpler molecules, volatile fatty acids (VFAs) occurs, producing ammonia, CO_2 and hydrogen sulfide as byproducts.
- acetogenesis - the simple molecules from acidogenesis are further digested by bacteria called acetogens to produce CO_2, hydrogen and mainly acetic acid.
- methanogenesis - methane, CO_2 and water are produced by bacteria called methanogens.

The pH level should be kept between 5.5-8.5 and the temperature between 30-60°C, in order to maximise digestion rates.[9]

Human Toxicity

Like most treatment processes, there will be some emissions from AD.

Air emissions are low due to the enclosed nature of the process, though combustion of the biogas will produce some nitrogen oxides. However, emissions from AD-CHP are generally lower than other forms of waste disposal.[5]

The health risk from the solid and liquid residue from the AD plant should be low as long as source-separated waste is being used (i.e. no chemical contaminants are entering the system from other waste).[5] Government control standards such as the Animal By-Products Regulation will determine if it can be spread on the land.

Case studies

South Shropshire Biowaste Digester

Greenfinch Ltd designed and installed an AD plant in South Shropshire in partnership with the South Shropshire District Council. It was constructed under Defra's New Technologies Demonstrator Programme and can be visited by anyone interested in finding out.

The process starts in an enclosed waste reception hall in which a biofilter controls emissions. After shredding, the waste is heated in tanks to 37 degrees centrigrade. After it has broken down, the material is pasteurised for an hour at 70 degrees so that it complies with the animal by-products regulations.

The plant has a capacity of 5000 tonnes each year at a cost of between £40 and £50 per tonne.[10] The biogas is converted into electricity and 800,000 kilowatts per hour is used to heat the plant. The pasteurised bio-fertiliser is offered to local farmers. The plant could produce around 4,320 tonnes of biofertiliser and 880 tonnes of biogas each year. In the future, biogas may be used in a local district heating system.

The plant began full operation in the first quarter of 2006 and initially processed source-separated kitchen waste and garden waste collected from households in South Shropshire. It was found there was too much garden waste in the mix to produce the most biogas possible, so the plant is now focussing on processing food waste.

Further information: http://www.greenfinch.co.uk/

BIOGEN plant in Milton Ernest, Bedfordshire

BIOGEN UK runs an AD plant at Milton Ernest in Bedfordshire which processes pig slurry and food manufacturers' waste. The plant also receives about twelve tonnes of food waste each week from Bedford County Council, Luton Borough Council and Milton Keynes Council. These councils are trialling weekly food waste collection schemes with support from the Waste & Resources Action Programme. BIOGEN say that each year their plant is capable of accepting up to 30,000 tonnes of food waste and 12,000 tonnes of slurry and can produce over 1MW of electricity (enough for 1,000 homes) and over 1.5MW of heat. The bio-fertiliser produced is used on the adjacent arable farmland.

Further information: http://www.biogen.co.uk/default.asp

AD and composting in Ypres, Belgium

Built in 2004, the Ypres anaerobic waste treatment plant has an annual capacity of 55000 tons. The plant produces enough energy to meet its own thermal and electrical energy demand and also sells more than half of its total generated electricity into the electric utility grid system, providing electricity for 2000 homes. The plant also incorporates an enclosed tunnel composting system producing high-grade compost.[11]

Conclusion

Anaerobic digestion provides an important opportunity to generate 100 per cent renewable energy from biodegradable waste. Research clearly indicates the most sustainable way to treat our food waste is to have separate weekly collections for treatment by AD. Strong backing in the new Waste Strategy should mean that we start to fulfil this potential, with the widespread introduction of food waste collections and the construction of more AD plants across the UK.

References

1 Greenfinch Ltd (2006), "Anaerobic digestion – an opportunity for rural diversification", Michael Cheshire, http://www.rics.org/Environmentalandlandconsultancy/Agribusiness/anaerobicdigestion010906.html

2 Eunomia (2006), "A Changing Climate for Energy from Waste", Dr Dominic Hogg, http://www.foe.co.uk/resource/reports/changing_climate.pdf

3 DEFRA (2007), "Waste Strategy for England 2007", http://www.defra.gov.uk/environment/waste/strategy/

4 Friends of the Earth (2006), "Dirty Truths: Incineration and Climate Change", http://www.foe.co.uk/resource/briefings/dirty_truths.pdf

5 DEFRA (2004), "Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes", http://www.defra.gov.uk/environment/waste/research/health/index.htm

6 ERM (2007), "Carbon Balances and Energy Impacts of the Management of UK Waste Streams", http://www2.defra.gov.uk/research/project_data/More.asp?I=WR0602

7 Eunomia (2007), "Dealing with food waste in the UK", Dr Dominic Hogg et al, http://www.wrap.org.uk/document.rm?id=3603

8 ENDS Report 329 (2002), "Water sector awakes to energy test", p25

9 Themelis.N.J &.Verma.S (2004), "The Better Option, anaerobic digestion of organic wastes in MSW. Waste Management World"

10 Eunomia (2007), "Managing Biowastes from Households in the UK: Applying Life-cycle Thinking in the Framework of Cost-benefit Analysis", http://www.wrap.org.uk/document.rm?id=3824

11 Biocycle (2004), "Combining anaerobic digestion with enclosed tunnel composting", Joerg Blischke, http://www.bta-technologie.de/files/AD_Plant_Ieper.pdf