Fact sheet
Energy 02
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02

ANAEROBIC DIGESTION

Introduction

Anaerobic digestion (AD) is the conversion of feedstock (any organic non-woody material) by micro-organisms in the absence of oxygen into biogas and digestate. It is a natural process and is well understood by mankind, having been harnessed for many years.

The AD process

Manure and other possible biomass feedstocks are inserted into a large, sealed airless container. In this oxygen-free environment, bacteria will produce biogas. In most digesters, the contents will be heated to accelerate the process. The produced biogas can be used to generate heat or electricity or both. This last option of combined heat and power (CHP) is the most common. The electricity that is generated through the gas engine can be either supplied to the electricity grid or used for own consumption. The heat can be used for the digester, with the surplus sold and used for heating residential or commercial buildings. AD can be applied at a range of scales, depending on the amount of biomass available. Systems can range from small farm-based digesters to large centralised anaerobic digesters (CAD) supplied with feedstocks from several sources. The microbial process of AD requires careful management to maximise its potential output. There are several design options, which have different cost implications and return varying efficiencies, including:

- operation temperatures;
- moisture levels;
- continuous or batch system;
- single, double or multiple digesters; and,
- vertical or horizontal tank layout.

AD feedstocks

- Slurries (cattle/poultry/pigs);
- domestic food waste (brown bin waste);
- food processing waste;
- crops grown specifically for AD (wholecrop wheat/maize); and,
- silage/grass.

Table 1: Biogas composition.

Methane (CH_4)	50-80%
Carbon dioxide (CO_2)	20-50%
Nitrogen (N_2)	<1%
Hydrogen (H_2)	<1%
Ammonia (NH_4)	<1%
Hydrogen sulphide (H_2S)	<1%

The produced biogas consists of methane (CH_4) and carbon dioxide (CO_2) together with minor quantities of nitrogen (N_2), hydrogen (H_2), ammonia (NH4) and hydrogen sulphide (H_2S). Biogas from feedstocks with high carbohydrate content, such as cattle manure, has a relatively low methane content.

Raw biogas can be used to generate heat and/or power. It can also be upgraded to biomethane, which can be injected into the national gas grid or used as a transport fuel.

Biomethane

Ireland's biogas industry will centre on upgrading biogas to biomethane for injection into the national gas grid. Before injection into the grid, biogas has to undergo further upgrading to remove CO2 and other trace gases. This process creates biomethane, with a methane content of around 99%. Biomethane closely resembles the properties of natural gas.

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Table 2: Benefits of AD to various sectors.

Farmers	Food processors	Local community	Environment	Government
Profit	Food waste removal	Less smell	Less nitrate pollution	Landfill Directive
Support for livestock	Cheap option	Local renewable energy	No net greenhouse gas (GHG) release	Nitrates Directive
Nitrates Directive	Good image	Local heat supply	Diverts landfill	Renewable
Available nutrients		New jobs	Diverts incineration	Fuel security
Diversification		Cleaner environment	Replaces manufactured nitrogen	Biofuel obligation
Pathogen kill			Carbon saving	Decentralised electricity
Weed seed kill				

Table 3: Energy content of farm feedstocks.

Feedstock	Biogas potential m^3 per tonne	DM content
Cattle	19.69	8%
Pig	14.28	4%
Poultry	50-250	14-70%
Farmyard manure (FYM)	49-66	20-27%
Grass	98-189 (fresh silage)	19-37%
Maize silage	155	30%
Barley straw	383	80%
Chopped molasses	363	75%

Table 4: Energy in biogas.

	Energy value
$1m^3$ biogas	23MJ
Electricity only	1.7kWh
Heat only	2.5kWh
CHP of biogas	1.7kWh and 2kWh

Benefits of digestate

- Destruction of weed seeds – dependent on retention time, process temperature, etc.;
- avoidance of plant burns – burns caused by low-density fatty acids – most fatty acids break down in the AD process; and,
- fertiliser improvement – mineralisation of organically bound nutrients – total phosphorus (P) vs available P.

Grass or maize yields

If we assume reasonable commercial farming conditions, with grass swards closed on March 31, then a single-cut system with harvesting on June 12 would produce 5.5 tonnes of silage DM/ha, while a two-cut system with sequential harvesting on June 5 and July 31 would yield 4.8 and 4.0 tonnes of silage DM/ha, respectively (all these values are silage DM rather than grass DM). If this two-cut system was extended and a third cut was taken in mid September, the later cut should produce about 3.0 tonnes silage DM/ha. Of course, if the harvest dates were altered, these values would also change. The default yield values which Teagasc uses for maize silage are 11.5 tonnes and 13.5 tonnes DM/ha for the 'no plastic mulch' and 'plastic mulch' systems, respectively.

Economics

The economics will depend on the scale of the digester and the availability of feedstocks being digested. AD requires a high capital cost and payback will be determined by the price received for the renewable electricity produced. There is currently no Renewable Energy Feed-in Tariff (REFIT) supporting AD in the Republic of Ireland. Economics are not favourable for digesting energy crops/grasses; however, with access to food wastes and the availability of a gate fee, certain projects may become viable, and would require a detailed feasibility study to justify investment.

Summary

- Economics are variable depending on scale and mix of feedstock;
- waste handling potential is also of interest to the food processing sector;
- working with local 'waste' suppliers and heat/power users improves the economics significantly; and,
- payback is dependent on a suitable REFIT for the substrate being digested.

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Further information

For further information please contact Barry Caslin, Teagasc, Rural Economy Development Programme at:
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The following resources are also helpful:

www.renewablegasforum.com
www.seai.ie/publications/Assessment-of-Cost-and-Benefits-of-Biogas-and-Biomethane-in-Ireland.pdf
www.cre.ie/web/wp-content/uploads/2019/07/IrBEA-Cre-Biogas-Policy-Paper-Final_1.pdf
www.irbea.org/biogas-and-anaerobic-digestion/

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