Improving the Welsh Dairy Supply Chain

Anaerobic digestion

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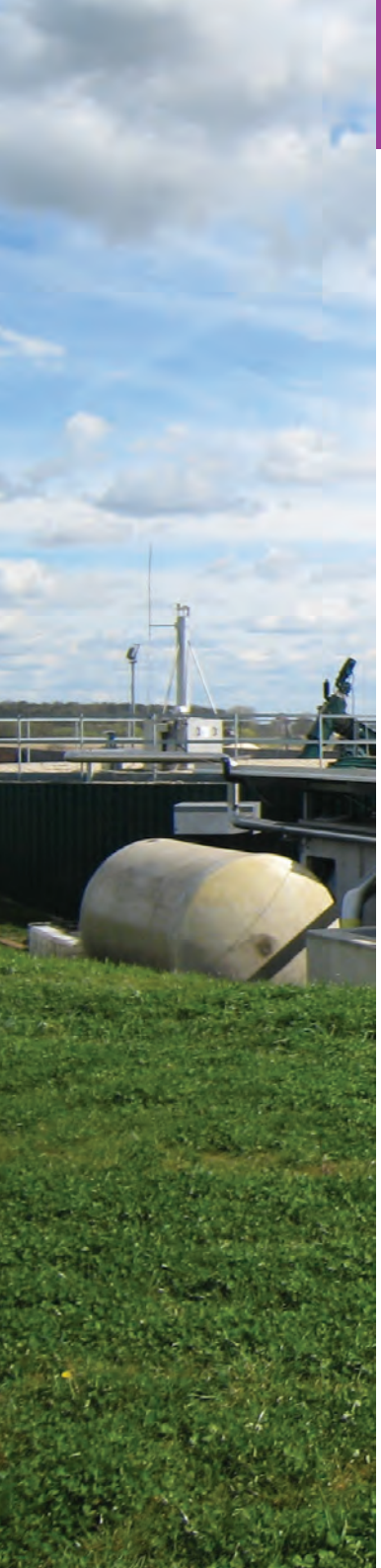

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Anaerobic digestion - turning muck into money

Anaerobic digestion (AD) is not a new technology and has been used for centuries to produce heat and gas (alongside a fertile digestate) from the process of breaking down biodegradable material in an enclosed digester. It's clear that farms, being in the business of producing such materials are in a prime position to take advantage of this technology.

Today AD has become very sophisticated with mainly European companies developing systems in order to support their aggressive move towards renewable energy systems. With the advent of support mechanisms for renewable energy in the UK - namely, the Feed in Tariff (FiT) and Renewable Heat Incentive (RHI), the profile of AD in the UK has also increased.

What are the practicalities and economics?

AD technology

AD is the process of decomposition of organic matter by bacteria in the absence of oxygen, typically at 37°C (Mesophilic) or at higher temperatures (Thermophilic) to produce biogas with a 50% - 60% methane content (most of the other gas is CO^2.) Feedstock can be farm manures and slurry, energy crops such as whole crop maize, beet or grass silage. Other biodegradable matter, such as food waste is also popular.

The table below shows the likely gas yield per tonne of raw feedstock:

Feedstock	Biogas yield m^3/t
Cattle slurry	15 – 25
Pig slurry	15 – 25
Poultry manure	30 – 90
Grass silage	160 – 200
Maize silage	200 – 220
Whole crop wheat	185
Wheat	610
Rapemeal	620

Materials that decompose faster and have a high energy density will produce more gas (such as food waste and energy crops) within a given time period than those such as straw or slurry which take longer to decompose or have a lower energy density. Some combinations of feedstock, or co-digestion, deliver a higher gas yield and a more stable process than others.

Digestion takes place in a specially designed sealed tank. The design will depend on the volume and dry matter of the feedstock but the three most common types are, Continuously Stirred Tank Reactors (CTSR's), Plug Flow Reactors and Batch Reactors.

CTSR is the design most commonly used in farm AD plants and have tanks with a propeller, paddle or a recirculated gas agitation system. Yearly output will depend on seasonal conditions. But an average full power equivalent of 30% to 50% of the rating (kW) might be expected.

Gas is burnt directly in a boiler or used to fuel an engine and generator to produce electricity. These Combined Heat and Power (CHP) engines also produce heat, which is recovered and can be utilised for space or process heating. More recently some large systems have been able to inject gas directly into the gas network, although this requires some cleaning and calorific balancing to deliver the required energy value per unit volume.

Combined Heat and Power (CHP) engine

AD returns

There are financial incentives available to support the operation of an AD installation. These are:

- The Renewables Obligation or the Feed in Tariff (FIT) which provide a payment for electricity generated. The system used and the rate of payment depends on the size of the plant.

- Renewable Heat Incentive (RHI) supports the supply of heat from heat exchangers rated up to 200kWth, or the direct injection of cleaned biogas into the gas network.

Both the FiT and RHI support requires the plant to be registered and approved by The Office of Gas and Electricity Markets (Ofgem).

Costs and output – farm scale AD

An example of a small scale AD plant

If we consider a 100 cow dairy unit and a 175m^3 digester costing around £125,000 the approximate input/output AD figures are:

Annual value of electricity from FiT's would be about £10,000, and export electricity £7,000. Heat might be worth about £2,000, giving a total output value in the region of £21,000 and a simple payback of 6-7 years. The worth of the digestate for use as a bio-fertiliser should also be taken into consideration.

Item	Amount
Slurry (8% Dry Matter)	6.6 t/day
Gas produced	106 m^3/day
Energy from gas	647 kWh/day
Electricity generation	208 kWh/day
Net Heat available	138 kWh/day
Parasitic load	21 kWh/day

When considering economics it's important to factor in the operational costs including, feedstock, management, maintenance and the parasitic loads (the amount of energy required to operate the plant) of the digester itself.

Digestate is a valuable fertiliser

Returns from on farm AD projects are highly sensitive to the cost of feedstock. Best returns therefore come from waste products. Furthermore, as heat is a bi-product, it helps if this can be utilised on site. An example of this is an AD facility on a dairy farm utilising slurry and providing heat and power to the dairy unit and domestic dwelling as well as exporting the surplus electricity to the national grid.

Planning and development

AD plants are often somewhat more challenging than other renewable options as they need to take into account the availability of a good long term source of feedstock. Planning permission and connection to the electricity grid can also be a challenge as the perception of the local community in terms of smell, traffic movement and safety need to be managed.

One advantage of the technology is that the operational 'load factors' are high – which means that unlike wind and solar, generators work at full output for long hours. As such, even modest sized systems can provide a substantial energy output over a typical year.