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Humshaugh Net Zero CIC

RCEF

Low Carbon Feasibility Study

Workstream 9 – Anaerobic Digestion

Final Report

February 2021

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2	Second Draft Report following client comments	Jan 2021
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(REF: 1601)

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D3 Associates Ltd

Report for

Humshaugh Net Zero CIC

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1 Introduction

Humshaugh Net Zero CIC (HNZ) are engaged in the process of reducing the Parish's carbon footprint, tackling climate change and to achieving the Government and Northumberland County Council Net Zero targets. They have consulted with the local community to ascertain their views and are looking to identify a viable approach to low carbon energy generation, particularly electricity, in the Parish of Humshaugh.

The Rural Community Energy Fund (RCEF) is a £10 million programme to support rural communities in England to develop renewable energy projects. HNZ have been successful with a stage 1 application, the funds being used to deliver this feasibility study. Stage 2 grants are available to further develop identified feasible projects for business development and planning.

1.1 Description of the Brief

Workstream 9 of this study is to assess the potential for anaerobic digestion (AD) within the Parish. The key elements in the Scope of Work are:

- Technology Review
- The AD process
- Biogas production
- Biogas uses
- Digestate
- Budget costs and funding

2 Technology Review

Anaerobic digestion offers a significant step towards more sustainable farming, reducing methane emissions, and is an ideal way to treat slurry. In addition, due to the governments Feed-in Tariff (FIT) and Renewable Heat Incentive (RHI) schemes, installing AD plant has become a means to generate renewable electricity using a combined heat and power (CHP) plant which runs off the biogas from the AD process.

AD is a microbial process which breaks down organic matter into simpler chemical components in the absence of oxygen, resulting in the production of biogas together with liquid and solid digestate. The process is particularly useful for wet biomass and residues which are less suited to thermal conversion, because transport and drying would require large energy inputs. The technology for AD is most advanced with liquid and semi-liquid slurries although there is considerable potential and more recent experience with food and drink waste and specifically grown crops.

AD is well suited to decentralised energy production in small-scale installations where biomass or wastes are locally available and is probably the most environmentally friendly option for treating them.

The following waste feedstocks are particularly suited to anaerobic digestion:

- Cattle and pig (manure and slurry)
- Poultry manure
- Silage effluent
- Industrial waste – from: food, brewing and soft drinks, distillery, pulp and paper, chemical industries etc.
- Sewage sludge – provides sanitisation and reduces odour potential
- Organic fraction of municipal solid wastes

Anaerobic digestion is the decomposition of biomass through bacterial action in the absence of oxygen. It is essentially a fermentation process and produces a product biogas which is a mixture of methane (50-70%) and carbon dioxide (25-45%) with traces of minor impurities. It is the same biological process that occurs in a landfill site but under controlled conditions in a digester. It is a four stage process: hydrolysis, acidification, acetogenesis and methanogenesis, each stage requiring different bacteria and conditions to undertake the process.

Before being digested, the feedstock must undergo pre-treatment. There are various types of pre-treatment depending on the feedstock. The purpose of such pre-treatment is to mix different feedstocks, to add water or to remove undesirable items and inert materials to allow a better digestate quality and increase the surface area of materials therefore enabling a more efficient digestion process.

Digesters can be characterised by the temperature at which they operate; mesophilic which operates at about 30-35^{0}C and thermophilic which operates at about 50-60^{0}C. In addition to the production of biogas, valuable by-products are the nutrient rich liquid and the residual digestate which can be used as a soil conditioner reducing the need for fertilisers. Some of the biogas produced is commonly used maintain constant temperatures within the digester either directly or from a CHP unit.

There are currently around 600 operational AD plants in the UK. The majority of plants are linked directly to CHP plants where the biogas is used to generate electricity and heat. This includes about 90 plants where the biomethane produced is fed directly into the gas grid (btg) helping to decarbonise the gas network.

2.1 AD Process

The two main types of anaerobic digestion are:

Mesophilic digestion

The digester is heated to 30-35^{0}C and the feedstock remains in the digester for typically 15-30 days (time needed to achieve complete degradation of the organic matter). This tends to be more robust and tolerant than the thermophilic process, but gas production is less, larger digestion tanks are required and sanitisation (to remove bugs) if required is a separate process. Mesophilic digestion is the most common approach since it is more reliable and plant management is easier.

Thermophilic digestion

The digester is heated to 50-60^{0}C and the residence time is typically 12-14 days. Thermophilic digestion offers higher methane production, faster throughput, better pathogen kill but requires more expensive technology, greater energy input and a higher degree of sensitivity to operating and environmental variables.

Mesophilic digestion is more suitable to slurries and solid waste where the longer retention time is needed for adequate anaerobic degradation. The digester itself is essentially a heated tank with a stirrer. The heat is required for the bacteria to thrive and gentle stirring continuously ensures complete mixing of the contents to create a homogenous substrate. This ensures the solids remain in suspension, improves the contact between the microorganisms and substrate and prevents temperature stratification and formation of a surface crust.

Anaerobic Digesters can also be classified into single-stage (single reactor vessel), and multi-stage systems. Multi-stage systems (usually two) aim at optimising digestion and improving control of the process by separating the stages of digestion providing flexibility to optimise each of the reactions. Two stage systems are generally more efficient producing 6-8% more methane, but this higher yield does not generally pay for the additional capital cost.

Digester volumes can range from around 100m3 to several thousand cubic metres and can be horizontal or vertical units.

2.2 Biogas Production

The biogas yield from an AD plant naturally depends on various factors. Most important is the feedstock and the organic dry matter it contains which can be broken down to produce methane. Note, if the feedstock is subject to prolonged storage this process may have already started and potential energy production lost. In addition, is the type of digester, the retention time, its temperature and the carbon to nitrogen ratio: the optimum ratio is 20-30:1.

The table below shows the likely biogas yields of feedstocks available for use in the Humshaugh area. Maize is added as an example to highlight the energy yield of an alternative crop to grass silage. Note, dry matter refers to the dry content of the feedstock.

Feedstock	Dry Matter (%)	Biogas Yield (m3/t)
Cattle slurry	10	15-25
Pig slurry	8	15-25
Poultry	20	30-100
Grass silage	28	160-200
Maize silage	33	200-220
Maize grain	80	560

Table 1: Biogas yields from various feedstocks

1m^3 of biogas, at 60% methane content, converts to about 6.7kWh of energy or in a CHP unit around 2kWh electricity and 2.5kWh heat.

Table 1 shows that cattle and pig slurry have extremely low yields. To improve the output, grass silage or other crops, such as maize, can be added. In Northumberland, only a large farm or several smaller farms working together will be able to devote enough resources to the production of a crop feedstock for an all year round supply. Around Humshaugh, grass silage is essential for feeding livestock throughout the winter and it is unlikely that a small farm, particularly one with a tenant farmer, has enough surplus silage to use in an AD plant.

Northumberland has very few AD plants. The most notable in the area is the Codlaw Renewable Energy Ltd plant in Hexham which uses grass and maize, grown as part of crop rotation, specifically for feedstock. The biogas produced generates heat and electricity through their 499kWe and 600kWe CHP units; the electricity is fed directly into the grid. Approximately 30% of the heat generated is used in the AD process.

2.3 Biogas Uses

As stated earlier, some of the biogas production, up to 30%, goes into maintaining the heat of the digester. The surplus biogas has number of uses:

- The most common in the UK is for use directly in a CHP plant, in locations where there is an all year round local demand for the heat (preferable not essential) and a suitable grid connection allowing for the export of the electricity (essential).
- Following the removal of carbon dioxide from the biogas, the biomethane can be directly injection into the gas grid which, naturally, needs a suitable pipeline nearby.
- Once cleaned, as a transport fuel for vehicles that have been appropriately converted, a minor use in the UK though the emissions of NOx and particulates are low when compared with petrol or diesel vehicles.
- There are some smaller farm AD plants in the UK that just use the gas produced to heat the farm, however, these plants are rarely economically viable due to the high capital costs

2.4 Digestate

A farm based AD project is more likely to be financially viable if treated as part of an integrated farm waste management system where all the products are used. The valuable by-product to the biogas is a nutrient-rich liquid and solid fibrous digestate. This consists of left over indigestible material and dead micro-organisms, the volume being around 90-95% of the initial feedstock.

By using digestate instead of synthetic fertilisers savings can be made and carbon emissions lowered. All the nitrogen, phosphorous and potassium present in the feedstock will remain in the digestate as none is present in the biogas. However, the nutrients are considerably more available than in raw slurry, meaning it is easier for plants to make use of the nutrients.

For the digestate not to be considered as waste certain standards are required to be met (Quality Protocol and PAS110). If they do not, the digestate will be considered to be waste and waste management controls will apply to its handling, transport and application. If the standards are in place the digestate can be sold as bio-fertiliser.

The residual digestate can be stored on the farm and then applied to the land without further treatment or separated to produce fibre and liquor. The fibre can be used as a soil conditioner or compost and the nutrient-rich liquid as a fertiliser.

2.5 Budget Costs/Funding

AD plants have a high capital cost, typical costs are:

- Less than 0.5MW – up to £1m

- 1.5 to 4.5MW - £5-£10m

The key factors in determining the capital cost is the size of the plant, measured by its energy output, the type of process including the number of tanks and the grid connection for electricity export. The latter will require a 3 phase supply – refer to WS 6 Grid for availability within Humshaugh Parish.

The increase in installations in recent years in the UK is primarily due to the governments Feed-in Tariff (FIT) and Renewable Heat Incentive (RHI) schemes. The Codlaw plant in Hexham receives FIT for the electricity generated and RHI income for heat produced from each of the two CHP units. However, the FIT is now closed and the RHI will be closing to new applications on March 31st, 2021 which eliminates two main income streams.

Capital funding is now limited for new schemes, there is the Anaerobic Digestion Loan Fund (ADLF) for sums between £50,000 and £1,0000,000 with a maximum term of 5 years. In addition, there is an On Farm AD Loan Fund, a £3 million initiative designed to support farm-scale AD capacity in England. The fund was available to farms planning to build an AD plant with a capacity of up to 250 KWe and which had access to slurries or manures to use as feedstock. The fund was split into two parts. Farmers were first able to apply for a business plant grant of up to £10,000 to investigate the environmental and economic potential of building an AD plant on the farm. The second part was a capital loan up to £400,000, or a maximum of 50% of the project cost. The fund is available through the WRAP website though this is currently not accepting new applications.

Alternatively, the Green Investment Group was set up by the UK Government as a public company though bought by Macquarie in 2017. The Group offers capital investment to renewable energy projects. Energy from Waste, which includes anaerobic digestion, is a specific priority area for the bank.

3 Summary

AD is a useful way to dealing with farms wastes and reducing methane emissions, a harmful greenhouse gas. In addition, with the addition of a high energy feedstock such as grass silage or maize, can produce significant quantities of biogas which can be used to generate renewable heat and electricity in a CHP unit.

However, the installation of a community AD plant in the Humshaugh Parish area isn't particularly favourable and a project of this type is complicated to implement.

An ideal site needs to:

- Be large enough to accommodate the digester tank(s), residue storage tanks, building to house the CHP unit and feedstock storage areas
- Be located near to the feedstock source to reduce transport costs
- Have guaranteed access to a suitable high energy feedstock all year round – farm slurry will need the addition of a grass or maize crop
- Have sufficient manpower available to manage the feedstock, monitor the processes and handle the digestate
- Have close access to a suitable grid connection

In addition, plants have a high capital cost, a major barrier to most community projects. Also, with the closure of the FIT and RHI schemes, the income streams which have assisted in the growth of the industry, the financial viability is currently hard to justify.

There is a good example of an AD facility in Hexham, however, it isn't located at the farm but by the sewage works close to a main sub-station.