A FEASIBILITY STUDY INTO THE POTENTIAL FOR COMMUNITY ANAEROBIC DIGESTION IN LLANIDLOES

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1. Introduction

This study has been carried out by Greenfinch for Llanidloes Energy Solutions from which it is hoped the findings of this report will be put forward as part of a Concerto bid for Llanidloes which could potentially help the town towards its goal to become a sustainable energy community.

The objective of this study is to look at the feasibility of developing an anaerobic digester for Llanidloes to provide the town with a waste management and renewable energy facility that can maintain itself financially. As well as making a contribution to renewable energy, the anaerobic digester will also make a contribution to the low-carbon economy through benign waste management (the reduction of the uncontrolled emissions of methane) and through nutrient recycling (the replacement of "artificial" fertilisers).

Anaerobic digesters can be applied in a range of situations and circumstances therefore the findings within this report are broken down into sections; feedstock and waste transportation, biogas and bio-fertiliser utilisation, plant location, design and costing. The collaboration of this information will determine the value that an anaerobic digester could have for Llanidloes.

2. Regulations

Biogas technology for the treatment of organic wastes meets the strategic objectives of both existing and impending legislation, all emanating from the European Union.

2.1. The EU Landfill Directive sets out exacting targets for the reduction of the disposal of biodegradable waste to landfill. The agreed target dates for the UK are 2010, 2013 and finally 2020, by which time the maximum amount of biowaste permitted to be landfilled is 35% of that landfilled in 1995, since when there has been an annual increase in waste production in the UK of about 3%.

The biogas plant will help towards the diversion of biodegradable waste from landfill through beneficial recycling of organic waste.

2.2. The Animal By-Products Regulations, which became law in 2003, set out the standards by which animal by-products, including domestic kitchen waste, may be recycled as a biofertiliser through the natural biological processes of aerobic composting and anaerobic digestion. The objective of these regulations is to protect animal and human health by preventing the spreading of pathogenic organisms such as salmonella and e.coli.

Anaerobic digestion coupled with pasteurisation (70^{o}C for one hour) and operated to high professional standards, has been proved to eradicate these organisms.

2.3. The EU Waste Prevention and Recycling Thematic Strategy aims to promote more sustainable waste management and recycling where the potential exists for additional environmental benefits are to be made. i.e. the recycling of nutrients.

2.4. The Energy White Paper sets out specific targets for the reduction of green house gas emissions with a 60% decrease by 2050 and significant progress by 2020.

Anaerobic digestion can contribute to this two fold; the capture of greenhouse gases that would otherwise be released into the atmosphere, and the offsetting of carbon emissions (CO_2.equivalent) through the use of biogas and bio-fertilisers where fossil fuels would otherwise be used.

3. Feedstock

The anaerobic digester will be used to treat local bio-waste. All sources of local feedstock were considered which included waste from agriculture, food processors, retailers, sewage works and household bio-waste.

3.1. Feedstock Audit

3.1.1. Domestic Catering Waste

There are approximately 1200 households within Llanidloes where catering waste could be collected through a source separated kerbside collection. The kitchen waste would include vegetable peelings and trimmings, spoilt vegetables & fruit, fruit skins, used tea bags and coffee grounds, food scraps such as bread, cooked food waste, waste meat, fish, fat and bones, egg boxes and cereal cartons.

Previous Greenfinch research on the collection of household kitchen waste has shown that on average 4kg of kitchen waste per week is produced per household with a participation rate of 75%; within Llanidloes this will total 190 tonnes per year.

3.1.2. School Catering Waste

Catering waste can also be collected from the schools within Llanidloes. An average of 0.19kg of food waste per week per pupil[1] has been estimated with maximum pupil numbers of 774 in Llanidloes High School and 494 in the Junior School. This amounts to approximately 240kg of catering waste per week for 40 weeks.

3.1.3. Commercial Catering Waste

A survey was done within the town to find out how much bio-waste was produced within the local businesses; this included butchers, cafes, pubs, restaurants and green grocers. Most of the businesses already had outlets for their waste, for example, the butchers sent there waste to the kennels. There will always be café and restaurant waste that could be collected however it was very hard to get a feeling of exactly how much waste is produced, a figure of 10 tonnes per year is estimated for this study. It is certain that all businesses in the town strive to keep their waste to a minimum. There is currently a cardboard collection around the town; all other waste is taken by the weekly refuse collection.

3.1.4. Agricultural Waste

Llanidloes is a very rural area within Mid-Wales. The land supports extensive beef and sheep farmers who recycle all the manure produced in the winter months back onto their land. There is no real scope for the use of farm waste for the production of biogas. In the future local farmers may grow wet energy crops to be processed in the anaerobic digester for the production of biogas. In Germany there are currently 3,000 on-farm anaerobic digesters whose sole objective is the production of biogas for electricity. The same situation is occurring in Austria where farmers are buying in maize from Hungary to fuel their biogas plants.

3.1.5. Sewage Sludge

The local sewage treatment works, located on the A470 and owned by Severn Trent, were approached about the possibility of diverting the sludge through an anaerobic digester in the town. An anaerobic digester has recently been built in Newtown to take all the sewage sludge from the surrounding area so they need as much of there

[1] Survey in London Borough of Southwark – David Collins – 2004. Mainly ‘convenience food’ lunches.

own sludge as possible to be tanked to Newtown.

3.1.6. Abattoir Waste

Hamer International abattoir is located to the west of Llanidloes on the A470. They have a large throughput with 24,000 lambs per week in peak times and 200 steers per week throughout the year. The majority of their waste is currently sent to Pointons in Staffordshire where it is rendered; this includes all category 1 & 2 materials. (Appenidix 1 defines the ABPR categories.) Other waste, i.e. lairage (gutfill and manure) is stored for 90 days in a lagoon onsite after which it is transported onto farms to be spread on the land. Both of these disposal systems are costly; the cost of waste disposal to the abattoir is the second highest cost after wages. An anaerobic digester can redirect some of the waste currently going to be rendered, such as blood and soft offal, and recoup some energy from the lairage which would still end up going back to the land as a digested material.

3.1.7. Grass Verge Cuttings

In summer 2005 a study was carried out entitled 'Living Highways Project – A practical trial to investigate the feasibility of wide-scale collection of cuttings from roadside verges in Powys, for use in biogas and compost production'. The Living Highways Project is a partnership between Montgomeryshire, Radnorshire and Brecknock Wildlife Trusts, Powys County Council, and the Countryside Council for Wales.

If the collection of grass verge cuttings was to continue then this would provide the digester with feedstock for energy production during the summer months. The verges would be cut twice a year during the summer to a radius of 13km around Llanidloes this would include the roads A470 (N&S), B4518 (N&S), and A44. The mean average annual vegetation yield in 2005 was $373kg_{DM}.km^{-1}.y^{-1}$; the total length of roads calculated is 114km. This would give a total annual tonnage of $42t_{DM}.y^{-1}$ that could be fed into the anaerobic digester.

3.2. Feedstock Scenarios

The following feedstock scenarios seem the most likely to arise with the development of an anaerobic digester in Llanidloes.

Scenario 1	Tonnes per year	%
Household kitchen waste	190	75
School catering waste	10	4
Commercial catering waste	10	4
Grass verge cuttings	42	17
Total	252	100

Scenario 2	Tonnes per year	%
Household kitchen waste	190	1.5
School catering waste	10	0.1
Commercial catering waste	10	0.1
Grass verge cuttings	42	0.3
Abattoir waste	12,000	98
Total	12,251	100

4. Waste Collection

The waste services in Llanidloes currently includes the collection of black bag waste, a recycling bag for cans and plastic, a recycling bag for paper, card and textiles and a basket for glass. If it proves feasible to build an anaerobic digester in Llanidloes then catering waste, as a main feedstock, will need to be source separated with a kerbside collection. There are several options for the kerbside collection of kitchen waste.

4.1. Piaggio Waste Vehicle

A Piaggio waste vehicle is currently being used in Cym Harry for the separate collection of garden waste. This vehicle may be available in the short term but long term they plan to extend its use full time.

A Piaggio waste tipper vehicle which has a skip on the back and a wheelie bin lift would cost approximately £20,000. The skip would need to be covered to prevent spillages and odours from escaping; this could be done using a trailer cover that could be easily removed when collecting the waste. The running costs would be approximately £2,000 per year which includes fuel, maintenance, tax and insurance. The collection would take approximately 12 hours according to the Cym Harry collection figures. This collection system would be used purposely for the anaerobic digester so the operators of the plant could be employed to do the kitchen waste collection as their weekly duties.

Health and safety issues must be considered when looking at this different type of collection with particular reference to the lifting and emptying of the bins/bags into the skip. This could be done by putting the waste into the wheelie bin which would be at waste height. Once the wheelie bin is full then it can be mechanically tipped into the skip. A cover should be put over the top of the skip when the vehicle is about to move long distances, e.g. over 50m, to ensure that there are know spillages or odours released. There should be two operators collecting waste at all times to assist one another in a safe and efficient collection.

The waste itself would need to be separated out by the householder into a suitable container ready for collection. There are many options for this including paper bags that are substantial enough to hold wet kitchen waste or kitchen caddies. One thirty litre kitchen caddies cost in the region of £7; each household would require one caddie and then costs must take into account for the replacement of five percent of the caddies each year; this totals £8,400 initial capital cost with an additional annual cost of £420. Costs for the brown bags would be similar as each household would require 52 bags per year.

4.2. Survival bags

Survival bags are a relatively new concept which incorporates all collections into one using different coloured bags. The survival bag may be bright pint, into which the householder must put all their kitchen waste. This is then collected alongside the black bag refuse collection and taken to a site where the bags are tipped allowing the pink bags to be picked out and opened. The kitchen waste could either be put into an anaerobic digester vessel located onsite or transported offsite to an alternative location. Transport costs for this collection are already accounted for within the council's current waste budget; only the survival bags and a container for the householder to collect the waste in would need to be provided. Approximate costs for this would be £7 per kitchen caddy and £5 for a role of 52 survival bags. This would be an initial capital cost of £14,400, and an annual cost of £6420 which would replace five percent of the kitchen caddies and provide each household with their survival bags.

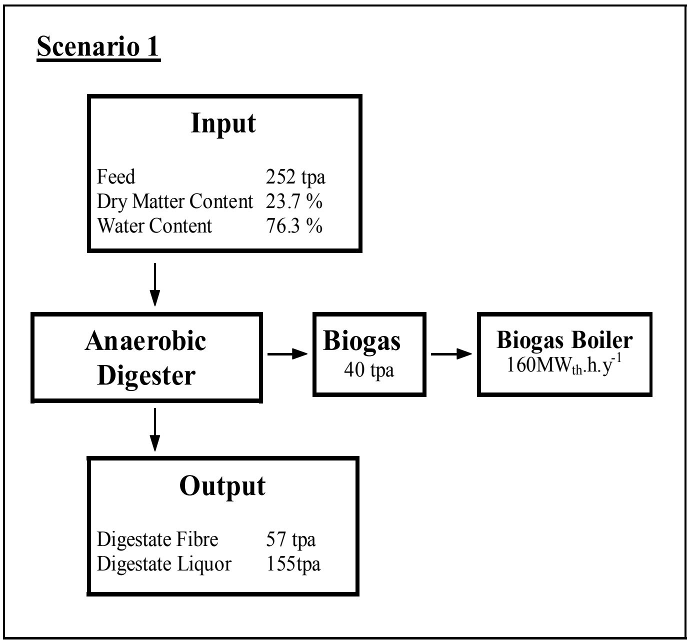
Additional labour costs for separation must be taken into account this could amount to

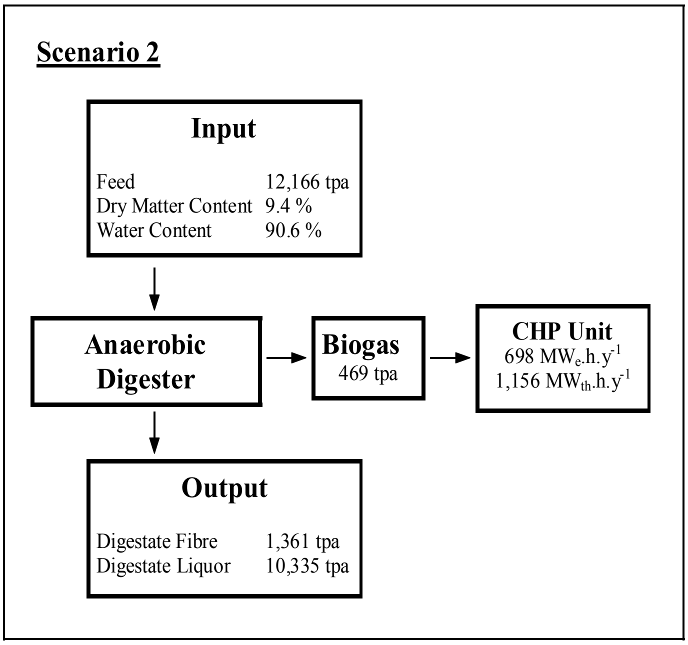
£16,000 per annum (two employees at £10 per hour for 16 hours per week). This final cost may not be incurred by the anaerobic digester as it may have to be tipped at a waste handling site where the waste streams can be separated and distributed accordingly. Under these circumstances the waste transfer site may incur the extra labour cost, but they may also take the gate for the waste which would take income away from the anaerobic digester.

The school catering waste and commercial catering waste would also need to be transported to the digester location. If the Piaggio were to be used then it would be feasible to collect the waste on alternative days to the household collection. It is presumed that the vehicle mowing the grass verges would be able to transport the grass to the digester. The abattoir waste would need to be transported using large haulage containers. It is not clear what the cost of this would be.

5. Mass Balance

The mass balance for each feedstock scenario can be seen below. The biogas boiler and combined heat and power unit (CHP) are used to give an idea of the energy value for the biogas.





These mass balances assume that the feedstock will be consistent throughout the year. In reality some of them will be seasonal; it is expected that if construction goes ahead then alternative feedstocks will be found when feedstock input is low, e.g. agricultural wastes, energy crops.

6. By-product Utilisation

6.1. Liquid and Fibre Digestate

The digestate should be used as a biofertiliser to recycle the nutrients back onto the local land for food and energy crop production. The price of oil is increasing the cost of mineral fertiliser which will make this organic fertiliser much more attractive to local farmers. The Renewable Power Association are about to undertake a study into establishing a Publicly Accepted Standard (PAS) for the digestate, this will be similar to the PAS 100 for composting. This digestate standard will help to promote and market the bio-fertiliser for beneficial use, giving consumers' confidence in this source-separated product. At present the spreading of digestate is covered under The Safe Sludge Matrix written by Water UK, ADAS, and British Retail Consortium specifically for the spreading of sewage sludge.

Scenario 1 may find it easier to market the bio-fertiliser as an exclusive product as there is very little of it. It may be possible to market the fibre to local residents as a soil conditioner for their gardens and the liquor as 'a liquid feed for your lawn'. Where possible a small fee should be charged for the product to increase the revenue for the biogas plant.

Scenario 2 should not have any problems in finding an outlet for the digestate, at the very least the digestate will given to farmers as a bio-fertiliser and this cost will be included as an expense to the digester within the economic assessment. There is a much larger quantity of digestate resulting from scenario two therefore it may be difficult to market it as an exclusive product with high value.

6.2. Biogas Utilisation

6.2.1. Combined Heat and Power Unit

A combined heat and power unit is an engine that transforms the biogas into heat and electricity which is the only way that Renewable Obligation Certificates can be claimed. CHP units are now designed to take un-scrubbed biogas with hydrogen sulphide levels of up to 500ppm.

The electricity should either have a direct use on site, or it should be put into the national grid. Both of these options require differing levels of capital investment depending on the specific requirements.

Scenario one does not warrant a CHP unit because of its low inputs and outputs.

Scenario two could support a $100kW_e$ CHP unit which would produce approximately 698 $MW_e.h.y^{-1}$ and 1,156 $MW_{th}.h.y^{-1}$. The CHP would have an availability of 95% with an electrical efficiency of 32%. The anaerobic digester would use a small amount of the heat and power itself, after which the surplus should be sold. Renewable electricity is currently worth approximately £85MW.h and heat £25MW.h.

6.2.2. Biogas Boiler

Biogas boilers are an efficient way of using the gas to produce heat, especially for smaller units. Cast iron boilers can be easily adapted to accept un-scrubbed biogas. A stand by boiler is required for maintenance purposes.

It is important that the heat is used as close to the plant as possible to minimise the energy loss through transportation.

Scenario one would support a 19kW boiler which would have 85% efficiency and 95 % availability. This would produce approximately $159MW_{th}.h.y^{-1}$.

Scenario two would probably have additional utilisation for the biogas, however a standby gas boiler will be included to use any excess gas, back up the alternative technology during maintenance work and heat the digester.

6.2.3. Alternative Utilisation Technologies

Alternative uses for the biogas are going to be researched under a separate feasibility study for Potters Waste Management at Brynposteg. This includes:

- Gas scrubbing & purification techniques for the removal of hydrogen sulphide and carbon dioxide using various chemical and biological methods.
- Connection to the mains gas lines specifically investigating the gas upgrade requirements and assessing how the Germans have recently made this link feasible.
- Gas compressing and transportation issues for use off site, i.e. for industrial/domestic gas heating
- Biogas used as a transport fuel to include filling station technicalities focusing on how Sweden is using biogas to fuel public transport.

It is hoped that this information will be completed and included as part of the Llanidloes Concerto bid.

6.3. Energy Use for Community Benefit

Community benefit from the anaerobic digester is an important output for this project; there are a number of possibilities on the school and leisure centre site where boilers are due to be replaced. This would be an ideal place for the heat to be used, both economically and socially.

An additional use for the heat is in glasshouses used for growing vegetables all year round. The carbon dioxide from the biogas can also be beneficial in a glasshouse environment increasing plant photosynthesis efficiencies. Llanidloes is a very rural area therefore the location of the digester is highly likely to have open land surrounding it. The glasshouses would need to be close to the digester to keep down the cost of transporting the heat and minimising energy loss over long distances. Maia Wells of Great Oak Foods would be very keen to push this idea forward if the study proves to be feasible and there could be money available from Glasu's New Harvest Project to fund the purchase of glasshouses if this is seen as a viable use of the energy. Maia would be keen to involve the community in such a project to educate the local people about growing their own food, and the recycling of waste for beneficial use.

7. Location

Location is perhaps one of the most important elements of this project; it has impact on the community with respect to seeing and being aware of the digester and the positive and negative social impacts this may have. Location may also have a role to play with the level of community benefit from the energy use, particularly the biogas.

7.1. School and Leisure Centre

The Children, and Lifelong Learning Department at Powys County Council were approached about the space availability for locating an anaerobic digester behind Llanidloes High School and Leisure Centre. There is insufficient space for an anaerobic digester to be developed on this Powys County Council Land. The owner of the farmland surrounding the back of the school, Keith Rollands, was approached by Llanidloes Energy Solutions and Greenfinch about the possibility of locating an anaerobic digester next to or on his land. He was very open to the idea and said that he would be happy to discuss the subject further if this study proved successful. The land would either need to be bought and rented from the farmer; it is not clear at this point what the cost of the land would be.

Access to the sight is down a narrow lane where only one vehicle can fit and which already becomes congested during the school peak times, i.e. 9am and 3:30pm. Widening the road or creating new access would be a costly process; a better solution to this problem would be to avoid deliveries and collections at these times. Glandulas Farm has access rights to the road so this would need to be discussed with the farmer.

There are plenty of outlets for the gas at this site. The sports hall, high school, canteen and primary school all have old boilers that need replacing. The school facilities require high heat loads during the winter with shut down during the summer. The sports hall requires a constant base load of approximately $100kW_{th}$ for the air handling system, swimming pool heating and possibly the secondary hot water. Scenario one will not produce enough biogas to meet this energy requirement with only $19kW_{th}$ from the biogas boiler. Scenario two will meet this requirement with approximately $139kW_{th}$ from a CHP unit and $223kW_{th}$ from a biogas boiler.

An alternative or additional use for the heat would be to locate glasshouses next to the digester. This idea is mentioned in paragraph 6.3 and would ensure that local school children especially benefited from the digesters location. If the biogas were to be scrubbed then the glasshouses would also benefit from the availability of carbon dioxide enhancing plant growth. This glasshouse idea was put forward to the local farmer who was certainly agreeable to the concept.

Positive points of locating the digester next to the school and sports hall are:

- It can be visually seen by the community making them aware of what is happening to their kitchen waste and encouraging them to become environmentally conscious;
- It is located close to the town where the kitchen waste will be collected keeping transport costs and carbon emissions to a minimum;
- The energy can be used for community benefit, either through heat and or electricity use within the site buildings, and or the heating of glasshouses for educational purposes.

Negative points of locating the digester next to the school and sports hall are:

- Access to the site would be down a lane where only one vehicle can pass and already gets congested during peak times;
- Some community members may not favour the idea of waste being transported past the

school premises.

7.2. KHT Site

The KHT site is currently being developed ready for the construction of industrial units. At present there are no units on site which may allow for the development of an anaerobic digester within the construction plans. The site is located on the edge of the town with a new separate access road from the B4518. The Welsh Development Agency is developing the site and was contacted regarding the study. It is not clear how many businesses have signed up for a unit which makes it hard to establish if there would be an immediate energy outlet for the digester; this is key to the financial stability of the project. There is a housing estate located next to the site which could allow for a domestic heating scheme using the excess heat from the digester but his would require extensive research, investment and time to set up such a project. The WDA did not rule out the idea of locating the anaerobic digester on this site, but there seemed to be no drive to do so at present with respect to energy demand.

Positive points of locating the digester on the KHP site:

- There is plenty of space to locate an anaerobic digester on the site;
- The access to the site is under construction and should not cause too many objections as it is on the outskirts of the town next to the by pass;
- There is enough agricultural land and space around the site to allow for the development of glasshouses.

Negatives points of locating the digester on the KHP site:

- There is no immediate outlet for the energy which is vital to the projects feasibility;
- Residents on the housing estate may object to locating an anaerobic digester next to their properties. Involvement of the community from the very start, including within this study, should help to prevent this kind of situation from arising.

7.3. Hamer International Abattoir

If scenario two proves to be the best feedstock selection, then the abattoir may be a location option for the digester, located outside Llanidloes along the A470. There is adequate space for a digester and separate access if required. The director of the abattoir was happy for the study to look at the possibility of locating the digester at their premises. It is not clear what the energy could be used for on site or what the energy requirement of the abattoir is. It may be feasible to use the excess heat in glasshouses next to the digester on site.

Positive points to locating the anaerobic digester next to the abattoir are:

- There is adequate space for an anaerobic digester;
- The site is has good access and is easily accessible off the main road;
- Scenario two is made up mostly of abattoir waste. Locating the digester at the abattoir would greatly reduce any transport costs and carbon emissions.

Negative points to locating the anaerobic digester next to the abattoir are:

- It is located away from the community, possibly out of sight out of mind;
- If the abattoir find uses for the energy produced by the anaerobic digester this may not give the community little benefit from the plant.

7.4. Brynposteg – Potters Waste Management

Potters Waste Management is looking into the feasibility of building an anaerobic digester to treat the organic fraction of municipal solid waste. This would be black bag waste that is shredded with the organics then separated out. It is not clear how much waste would be entering this digester but it would certainly be greater quantities than the waste within this feasibility study. Potter Waste Managment takes in waste from all over Powys. Brynposteg could be a suitable location for a community anaerobic digester because there is adequate space and access for such a set up, whether this is in addition or included within a Potters Waste Management digester. There is a recycling reception unit which is already equipped to receive and handle large quantities of waste. It is not clear what the energy from the digester could be used for, Potters Waste Management are about to look into the feasibility of various gas utilisation technologies as detailed in paragraph 6.2.3. There is agricultural land surrounding the landfill site so there is a possibility that glasshouses could be erected for hands on community benefit of the digester.

Positive points of locating a digester at Brynposteg are:

- Space and access would not be a problem;
- There are already facilities to receive large quantities of waste;
- Energy may be available for community benefit depending on the type of biogas utilisation technology chosen.

Negative points of locating a digester at Brynposteg are:

- It is located away from the community, possibly out of sight out of mind;
- If the source separated waste is treated in the same digester as the organic waste from the black bags, then the bio-fertiliser will become contaminated and may lose economic value.

There are positive and negative points for all the sites suggested above. Community benefit to be had from all of the sites is the reduced carbon emissions from landfill with the capture of methane to be used as a renewable energy, and offsetting carbon emissions caused by the use of fossil fuels.

8. Plant Design

The digester will be a continuously stirred tank reactor (CSTR) which is fed at timed intervals and kept at a temperature of 37^{o}C. The digester feedstock will be pumped or placed into a conditioning tank where it will be macerated and made into a ‘soup’ allowing the material to be easily pumped throughout the process. Macerating the material also enhances the digestion process allowing the bacteria more surface area to breakdown. The soup will be pumped into a raw waste buffer tank where the material will then be fed into the digester at regular intervals. The digester discharges into the pasteurisation tank where it is heated at 70^{o}C for one hour; pasteurisation is a batch process. The digestate is then discharged over a separator, with the solids collected into a pile underneath the separator and the liquid ending up in the digestate storage tank.

The digester operator would be required to take daily readings of the hours run metres for each pump located on the main control panel, which also includes the digester temperature. This ensures that if a problem occurs, e.g. a blocked pump or reduced feed, it can be located by looking at the daily readings.

Drawings of the plants can be seen in appendix 2 & 3. The plant footprint for scenario 1 is approximately 9m x 9m, and 40m x 28m for scenario 2.

9. Cost

A breakdown of all the costs can be seen on the economics spreadsheet in appendix 4 & 5.

9.1. Capital Cost

The anaerobic digesters for both scenario one and two will both be based on the set up described in paragraph 8 but with varying tank sizes.

9.1.1. Scenario 1

The selection of feedstock for scenario one is detailed in paragraph 3.2. The capital cost for this plant will be £250,000. This will include:

- Civil engineering including tank bases and plant room
- Tanks (conditioning tank, raw waste buffer tank, digester tank, pasteurisation tank & digestate storage tank)
- Plant room
- Gas holder
- Mechanical equipment
- Electrical equipment, instrumentation and controls
- Pipework
- Separator
- Biogas boiler
- Installation & commissioning

9.1.2. Scenario 2

The selection of feedstock for scenario two is detailed in paragraph 3.2. The capital cost for this plant will be £900,000. This will include:

- Civil engineering including tank bases and plant room
- Tanks (conditioning tank, raw waste buffer tank, digester tank, pasteurisation tank & digestate storage tank)
- Plant room
- Gas holder
- Mechanical equipment
- Electrical equipment, instrumentation and controls
- Pipework
- Separator
- Biogas boiler
- 100kW CHP unit
- Installation & commissioning

The capital cost for both scenarios includes only the services and equipment listed. Additional to the capital cost above is any work that may be required to change or create access to the plant which is dependant on the chosen location; any costs incurred through the gas utilisation are also not accounted for in the costs above, except for the biogas boilers and the CHP unit. The cost of utilities, i.e. gas, electricity, telephone and water, is not included within this price as this can vary depending on the location.

The cost of purchasing a waste collection vehicle will cost approximately £20,000 with the initial purchase of kitchen caddies at £8,400. The running costs of the vehicle including the collection costs will be discussed in paragraph 9.2.

9.2. Operating Costs

The operating costs will include labour, maintenance and spare, utilities, waste management license fees, laboratory costs, collection costs and possibly disposal of the bio-fertiliser. The operating costs for both scenarios are different; the breakdown can be seen in appendix 4 & 5.

9.2.1. Scenario 1

The operating costs of scenario one will be approximately £26,700. In addition to this the collection cost for the domestic and commercial catering waste would be £2,420 per year which includes fuel, insurance, tax, and the cost of replacement caddies. The labour cost of the collection is included within the plant operating costs.

9.2.2. Scenario 2

The operating cost of scenario two will be approximately £168,000. This includes collection costs of domestic and commercial catering waste which are detailed in paragraph 9.2.1. It is not clear what the collection costs of the abattoir waste will be as this will greatly depend on the digester location.

10. Revenue

The revenue of the anaerobic digester is vital to its financial sustainability. The gate fee is very important including the revenue from sales of heat, biofertiliser and electricity. The gate fee will alter depending on the type of waste imported i.e. abattoir waste that would otherwise be rendered demands a higher price than catering waste that would alternatively be land filled. The heat use from the plant should be maximised to full potential. The biofertiliser should be marketed at a cost to farmers, land owners, and gardeners from the very beginning. If it is given away free of charge at the start it will be very hard to ask people to pay for it thereafter.

10.1. Scenario 1

	Price per Unit	Income
Gate Fee	£40/tonne	£10,066
Heat	£25/MWh	£2,949
Solid Biofertiliser	£15/tonne	£858
Liquid Biofertiliser	£2/tonne	£330
Total		£14,203

10.2. Scenario 2

	Price per Unit	Income
Gate Fee	£40/tonne : domestic & commercial catering waste/grass verge waste £80/tonne : blood £20/tonne : lairage	£350,037
Electricity	£85/MWh	£59,343
Heat	£25/MWh	£9,691
Solid Biofertiliser	£10/tonne	£13,617
Liquid Biofertiliser	£0/tonne	
Total		£432,688

The gate fee would need to be negotiated with the appropriate businesses; it is very important that the gate fee is charged at a cost to make the plant financially viable.

It should be noted that Greenfinch has not done extensive work on the anaerobic digestion of abattoir waste; the figures within the process calculations for scenario two should be taken as an estimate with further research required to clarify these figures.

The revenue list above does not include charges for the collection of kitchen waste; at present this is incorporated in the operating costs without reclaiming the expense back off the council. This is something that would need to be negotiated at a later stage. The waste collection vehicle will be stationary for much of the week so there is also scope for it to be hired/contracted out for various other jobs to create further income.

11. Simple Economic Assessment

11.1. Scenario 1

Capital Cost	£278,400
Income	£14,203
Operating Cost	£29,097
Net Income	£-14,894
Annual Discount Rate	7%
Lifetime of Plant	15 years
Present Value of Net Income	£-135,654
Less Capital Cost	£-278,400
Net Present Value	£-414,054

11.2. Scenario 2

Capital Cost	£928,400
Income	£432,688
Operating Cost	£167,830
Net Income	£264,858
Annual Discount Rate	7%
Lifetime of Plant	15 years
Present Value of Net Income	£2,412,305
Less Capital Cost	£-928,400
Net Present Value	£1,483,905

12. Planning & Permitting

The development of an anaerobic digester treating imported waste and animal by products require the following permits.

- Planning Permission - Local/County Council

The price for this is included within the capital cost of the anaerobic digester.

- Waste Management License - Environment Agency

The price of purchasing the license is included within the capital cost, and the annual subsistence fee is included within the operation costs. These vary for the two scenarios as the price is based on tonnage of waste per annum. The economic spreadsheet in appendices 4 and 5 show the annual waste management licence fee.

- Animal By Product Regulation Approval - State Veterinary Service

This is funded by the Government.

13. Conclusion

There are many options for the feedstock combination, location, energy utilisation, and retailing of biofertiliser. There is no right or wrong combination but it is important that there are benefits for the community; more importantly it must be financially sustainable.

Greenfinch recommends the following scenario for a community anaerobic digester in Llanidloes. The best feedstock selection for waste treatment and biogas production would be scenario two. There is a good mixture of materials, with local catering waste, grass verge cuttings and abattoir waste including blood (which is currently treated in Staffordshire) and lairage (which is applied to the local land). By including the abattoir waste more biogas will be produced and carbon savings will be made through not having to transport the waste to Staffordshire. The lairage can still be applied to local land as a fertiliser after digestion.

The most appropriate location for an anaerobic digester, fed on the cocktail of material listed in scenario two (paragraph 3.2) would be at the abattoir itself. The bulk of the digesters feedstock would come from the abattoir which would keep down the transport costs and carbon emissions. There is adequate space for development at this site.

The most efficient way of collecting catering waste from Llanidloes would be the use of a Piaggio style tipper truck described in paragraph 4.1. The vehicle could be sign written to draw attention to it advertising the anaerobic digester; this is especially important if the digester is not located within the community itself. The vehicle would not be in full time use so it could be contracted out for alternative uses, or used to collect other local waste for the digester. This would bring in more revenue for the digester.

If the anaerobic digester was to be located at the abattoir then it is not clear what the direct use of the biogas would be. If there was no specific call for the biogas then it would be suggested that a CHP unit is used to produce electricity from the biogas. There will be a lot of excess heat from the CHP unit which should be captured and used to its full potential wherever possible. A strong suggestion for the use of the heat would be to pump it into glasshouses to grow fruit and vegetables all year round; this would help to create community involvement especially with the participation of local school parties and youth organisations. There are already people within the community interested in pushing this idea forward and it is highly likely that there would be funding available for such a sideline project detailed in paragraph 6.3.

The overriding fact that favours scenario two to be sited at the abattoir is the economics. Section 11 gives details of the simple economic assessment of scenarios one and two, showing that scenario two would be financially sustainable with a net present value of £1.5 million. Most of the revenue comes from the gate fee, but it is equally important that value is gained from the utilisation of the biogas and bio-fertiliser.

14. Glossery of Terms

CH_4	Methane
CO_2	Carbon Dioxide
CHP	Combined Heat & Power Unit
DM	Dry Matter
ODM	Organic Dry Matter
tpa	tonnes per annum
kW	kilowatt
kWth	kilowatt thermal
MW	megawatt
MW_{th}	megawatt thermal
$MW_e.h.y^{-1}$	megawatt electricity hours per year
$MW_{th}.h.y^{-1}$	megawatt thermal hours per year
$t_{DM}.y^{-1}$	tonnes of dry matter per year
$kg_{DM}.km^{-1}.y^{-1}$	kilograms of dry matter per kilometre per year

Appendix 1.

Classification of Animal By-Products, its Processing and Disposal.

Animal by-products are described as 'the entire bodies or parts of animals or products of animal origin not intended for human consumption including ova, embryos and semen'. The regulation has classified and sub-divided all animal by-products according to their safety and risk to human and animal health.

Category 1 Material

The highest risk material is classified as Category 1. This is any TSE- infected (transmissible spongiform encephalopathies) material such as brain and spinal cord, specific risk material and sludge collected from Category 1 processing plants. All these by-products are considered high risk with respect to transmissible prion infectivity. It also includes catering waste which is derived from international transportation due to the possible importation of exotic diseases. The safety concerns surrounding the disposal of TSE-infected material and internationally transported catering waste forces the direct disposal of Category 1material through incineration or landfill. The re-use of this material is not permitted in any form.

- All body parts suspected of being infected by TSE
- Animals killed in the context of TSE eradication
- Experimental animals
- Specified Risk Material
- All animal material collected when treating waste water from Cat 1 processing plants and other premises which specified risk material is removed including screenings, materials from desanding, grease and oil mixtures, sludge and material removed from the drain.

Category 2 material

The second classification, Category 2 material, covers all material that is not intended for human consumption and can not be placed on the market or exported. This includes by-products such as manure, digestive tract content, animal body parts that are either condemned or determined as contaminated by veterinary officials, and animal materials collected from slaughterhouse wastewaters. Category 2 material can be directly disposed of using incineration, or processed in a processing plant (Article 13) using an appropriate 'pressure cooking' method such as Method 1, heating to a core temperature of 133^{o}C, gaining absolute pressure of 3 bar for 20minutes. Processed category 2 material using Method 1 only, must be further transformed using an alternative processing method such as biogas technology. With regard to manure and digestive tract contents, it can be applied directly to land or transformed using biogas or composting.

- Manure and digestive tract contents (separated from the digestive tract, milk and colostrum
- All animal materials collected when treating waste water from slaughterhouses
- Products containing residues of veterinary drugs and contaminants
- Condemned animals or parts

Category 3 Material

Category 3 animal by-products are distinguished as those which were deemed fit for human consumption but for commercial reasons are no longer intended for human consumption. This low risk material includes soft offal, blood, hides, skins, hooves, feathers, raw milk, fish, and catering waste (produced within the EU). In addition to incineration and landfill, these animal by-products can be processed in a processing plant, transformed in a technical plant or used as raw material in a petfood plant. It may also be transformed in a biogas or composting plant.

- Parts of slaughtered animal fit for human consumption
- Parts of slaughtered animals which are rejected as unfit but have no signs of disease.
- Hides, skins, hooves, horns, pig bristles and feathers
- Blood
- Animal by-products from the production of products for human consumption including degreased bones and greaves
- Former foodstuffs of animal origin, or former foodstuffs containing products of animal origin (other than catering waste)
- raw milk
- fish
- shells, hatchery products and cracked egg by-products

Appendix 4

Llanidloes Scenario 1 **25/11/05**

DIGESTER FEEDSTOCK

Kitchen Waste

Mass	3.7	tonnes/week
%DS	22.5	% TS
%ODM	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.8	tonnes/week
Organic Dry Solids	0.8	tonnes/week
Methane Production	289	m3 CH4/week

School Catering Waste

Mass	0.2	tonnes/week
%DS	22.5	% TS
%ODM	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.0	tonnes/week
Organic Dry Solids	0.0	tonnes/week
Methane Production	15	m3 CH4/week

Commercial Catering Waste

Mass	0.2	tonnes/week
%TS	22.5	% TS
%DS	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.0	tonnes/week
Organic Dry Solids	0.0	tonnes/week
Methane Production	15	m3 CH4/week

Grass Verge Cuttings

Mass	0.8	tonnes/week
%DS	30.0	% TS
%ODM	85.0	% VS
Specific Methane Yield	300	m3 CH4/tODM
Dry Solids	0.2	tonnes/week
Organic Dry Solids	0.2	tonnes/week
Methane Production	61	m3 CH4/week

Total Digester Feedstock

Mass	4.8	tonnes/week
%DS	23.7	% TS
%ODM	90.9	% VS
Specific Methane Yield	364	m3 CH4/tODM
Dry Solids	1.1	tonnes/week
Organic Dry Solids	1.0	tonnes/week
Methane Production	380	m3 CH4/week

INCOME

Gate Fee	40	£/tonne
Waste Treatment	252	tonnes/year
Income from Gate Fee	**10,066**	**£/year**
Value of Electricity	85	£/MWh
Gross Electricity Production	0	MWh/year
Income from Electricity Sales	**0**	**£/year**
Value of Surplus Heat	25	£/MWh
Surplus Heat Production	118	£/year
Potential Value of Surplus Heat	2949	£/year
% Utilisation of Surplus Heat	100	%
Income from Surplus Heat	**2,949**	**£/year**
Value of Solid Biofertiliser	15	£/tonne
Value of Liquid Biofertiliser	2	£/tonne
Solid Biofertiliser Production	57	tonnes/year
Liquid Biofertiliser Production	165	tonnes/year
Income from Biofertiliser Sales	**1,188**	**£/year**
Total Income	**14,203**	**£/year**

OPERATING COSTS

Management	0	£/tonne
Cost of Management	**0**	**£/year**
Labour	63	£/tonne
Cost of Labour	**15,853**	**£/year**
Maintenance Contract	8	£/tonne
Cost of Maintenance & Spares	**2,013**	**£/year**
Cost of Electricity	80	£/MWh
Cost of Water	1	£/m3
Electricity Consumption	10	MWh/year
Water Consumption	10	m3/year
Cost of Utilities	**810**	**£/year**
Cost of Solid Biofertiliser Disposal	0	£/tonne
Cost of Liquid Biofertiliser Disposal	0	£/tonne
Solid Biofertiliser Production	57	tonnes/year
Liquid Biofertiliser Production	165	tonnes/year
Cost of Disposal of Biofertiliser	**0**	**£/year**
Waste Management License	2,000	£/year
Laboratory Costs	1,000	£/year
Collection Costs	2,420	£/yr
Office Costs	0	£/year
Miscellaneous Costs	5,000	£/year
Other Operating Costs	**10,420**	**£/year**
Total Operating Cost	**29,097**	**£/year**

ECONOMIC ASSESSMENT

Capital Cost	278,400	£
Income	14,203	£/year
Operating Cost	29,097	£/year
Net Income	-14,894	£/year
Annual Discount Rate	7	%
Lifetime of Plant	15	years
Present Value of Net Income	-135,654	£
Less Capital Cost	-278,400	£
NET PRESENT VALUE	**-414,054**	**£**

Feedstock Conditioning & Storage

Mass of Organic Waste	4.8	tonnes/week
%DS of Organic Waste	23.7	% TS
%ODM of Organic Waste	90.9	% VS
Dry Solids of Organic Waste	1.1	tonnes/week
Organic Dry Matter of Organic Waste	1.0	tonnes/week
Mass of Process Water	0.2	tonnes/week
Mass of Digestate Liquor Recirculation	4.8	tonnes/week
%DS of Digestate Liquor Recirculation	3.6	% TS
%ODM of Digestate Liquor Recirculation	68.0	% VS
Dry Solids of Digestate Liquor Recirculation	0.2	tonnes/week
Organic Dry Matter of Digestate Liquor Recirculation	0.1	tonnes/week
% Organic Waste Rejected as Inert	0.0	%
Mass of Inert Rejects	0.0	tonnes/week
%DS of Inert Rejects	0	%
%ODM of Inert Rejects	0	%
Dry Solids of Inert Rejects	0.0	tonnes/week
Organic Dry Matter of Inert Rejects	0.0	tonnes/week
Mass of Digester Feedstock	9.8	tonnes/week
Dry Solids of Digester Feedstock	1.3	tonnes/week
Organic Dry Matter of Digester Feedstock	1.2	tonnes/week
Specific Gravity of Feedstock	1.04	tonnes/m3
Volume of Digester Feedstock	9.4	m3/week
Capacity of Conditioning Tank	1	m3
Storage Time Available in Conditioning Tank	0.4	days
Capacity of Raw Waste Buffer Tank	6	m3
Storage Time in Available in Raw Waste Buffer Tank	4.6	days

Anaerobic Digestion

Mass of Digester Feedstock	1.4	tonnes/day
Volume of Digester Feedstock	1.3	m3/day
%DS of Digester Feedstock	13.4	% TS
%ODM of Digester Feedstock	87.9	% VS
Dry Solids of Digester Feedstock	0.2	tonnes TS/day
Organic Dry Matter of Digester Feedstock	0.2	tonnes VS/day
Capacity of Digester	35	m3
Methane Production	54	m3 CH4/day
% Methane	60	% CH4
Volume of Biogas	90	m3/d
Specific Gravity of Biogas	1.21	kg/m3
Mass of Biogas	110	kg/d
Mass of Digester Output	1.3	tonnes/day
%DS of Digester Output	6.1	% TS
%ODM of Digester Output	71.1	% VS
Dry Solids of Digester Output	0.1	tonnes/day
Organic Dry Matter of Digester Output	0.1	tonnes/day
Specific Gravity of Digester Output	1.02	tonnes/m3
Volume of Digester Output	1.3	m3/day
Hydraulic Retention Time	**26**	**days**
%TS of Digester Feedstock	**13.4**	**% TS**
Specific Loading Rate	**4.7**	**kg VS/m3/day**
Biogas Production per day : Digester Capacity	**2.6**	**m3/d/m3**
Biogas Production : m3 Digester Feed	**67**	**m3/m3**
Biogas Production : Tonnes of Organic Waste	**131**	**m3/tonne**
Methane Production : Tonnes Organic Waste Organic Dry Matter	**364**	**m3/tonneODM**

Biogas		
Biogas Production	90	m3/day
Biogas Flow	4	m3/hour
% Methane	60	% CH4
Calorific Value of Biogas (LCV)	21.4	MJ/m3
Fuel Value of Biogas	1,936	MJ/day
Fuel Value of Biogas	22	kWf
Combined Heat & Power		
Fuel Value of Biogas	22	kWf
Electrical Efficiency	35.0	%
Thermal Efficiency	50.0	%
Electricity Output	8	kWe
Heat Output	11	kWth
Availability of CHP Unit	0	%
Annual Electricity Output	0	MWh/yr
Annual Heat Output	0	MWh/yr
Gas Boiler		
Fuel Value of Biogas	22	kWf
Thermal Efficiency	85.0	%
Heat Output	19	kWth
Gas Boiler Operating Time	95	%
Annual Heat Output	159	MWh/yr
Heat Requirement		
Volume of Digester Feedstock	1	m3/day
Temperature of Digester Feedstock	10	^{o}C
Temperature of Digester	37	^{o}C
Temperature of Outside Air	10	^{o}C
Heat Input to Digester Feedstock	153	MJ/day
Total Surface Area of Digester	61	m2
Thickness of Insulation	100	mm
Average Thermal Conductivity of Insulation	0.034	W/m.^{o}C
Digester Heat Loss	49	MJ/day
Total Digester Heat Requirement	201	MJ/day
Total Digester Heat Requirement	2.3	kWth
Volume of Pasteurisation Feedstock	1	m3/day
Temperature of Pasteurisation Feedstock	37	^{o}C
Temperature of Pasteurisation Tank	71	^{o}C
Temperature of Outside Air	10	^{o}C
Heat Input to Pasteurisation Feedstock	181	MJ/day
Total Surface Area of Pasteurisation Tank	10	m2
Thickness of Insulation	100	mm
Average Thermal Conductivity of Insulation	0.034	W/m.^{o}C
Pasteurisation Tank Heat Loss	18	MJ/day
Total Pasteurisation Heat Requirement	198	MJ/day
Total Pasteurisation Heat Requirement	2.3	kWth
Total Heat Requirement	400	MJ/day
Total Heat Requirement	41	MWh/yr
Electricity Balance		
Electricity Output	0	MWh/yr
% Parasitic Electricity	#DIV/0!	%
Electricity Consumption of Plant	10	MWh/yr
Net Electricity Output	**-10**	**MWh/yr**
Heat Balance		
Heat Output	159	MWh/yr
% Parasitic Heat	26	%
Heat Consumption of Plant	41	MWh/yr
Net Heat Output	**118**	**MWh/yr**

Appendix 5

Llanidloes Scenario 2 **25/11/05**

DIGESTER FEEDSTOCK

Kitchen Waste

Mass	3.7	tonnes/week
%DS	22.5	% TS
%ODM	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.8	tonnes/week
Organic Dry Solids	0.8	tonnes/week
Methane Production	289	m3 CH4/week

School Catering Waste

Mass	0.2	tonnes/week
%DS	22.5	% TS
%ODM	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.0	tonnes/week
Organic Dry Solids	0.0	tonnes/week
Methane Production	15	m3 CH4/week

Commercial Catering Waste

Mass	0.2	tonnes/week
%TS	22.5	% TS
%DS	92.5	% VS
Specific Methane Yield	380	m3 CH4/tODM
Dry Solids	0.0	tonnes/week
Organic Dry Solids	0.0	tonnes/week
Methane Production	15	m3 CH4/week

Grass Verge Cuttings

Mass	0.8	tonnes/week
%DS	30.0	% TS
%ODM	85.0	% VS
Specific Methane Yield	300	m3 CH4/tODM
Dry Solids	0.2	tonnes/week
Organic Dry Solids	0.2	tonnes/week
Methane Production	61	m3 CH4/week

Abattoir Waste - Blood

Mass	32.5	tonnes/week
%DS	4.0	% TS
%ODM	90.0	% VS
Specific Methane Yield	350	m3 CH4/tODM
Dry Solids	1.3	tonnes/week
Organic Dry Solids	1.2	tonnes/week
Methane Production	410	m3 CH4/week

Abattoir Waste - Lairage (Manure & Gutfill

Mass	196.0	tonnes/week
%DS	10.0	% TS
%ODM	77.0	% VS
Specific Methane Yield	242	m3 CH4/tODM
Dry Solids	19.6	tonnes/week
Organic Dry Solids	15.1	tonnes/week
Methane Production	3,652	m3 CH4/week

Total Digester Feedstock

Mass	233.3	tonnes/week
%DS	9.4	% TS
%ODM	78.5	% VS
Specific Methane Yield	257	m3 CH4/tODM
Dry Solids	22.0	tonnes/week
Organic Dry Solids	17.3	tonnes/week
Methane Production	4,441	m3 CH4/week

INCOME	
Biowaste	40 £/tonne
Blood	80 £/tonne
Lairage	20 £/tonne
Gate Fee (Average)	**29 £/tonne**
Waste Treatment	12166 tonnes/year
Income from Gate Fee	**350,037 £/year**
Value of Electricity	85 £/MWh
Gross Electricity Production	698 MWh/year
Income from Electricity Sales	**59,343 £/year**
Value of Surplus Heat	25 £/MWh
Surplus Heat Production	388 £/year
Potential Value of Surplus Heat	9691 £/year
% Utilisation of Surplus Heat	100 %
Income from Surplus Heat	**9,691 £/year**
Value of Solid Biofertiliser	10 £/tonne
Value of Liquid Biofertiliser	0 £/tonne
Solid Biofertiliser Production	1362 tonnes/year
Liquid Biofertiliser Production	10336 tonnes/year
Income from Biofertiliser Sales	**13,617 £/year**
Total Income	**432,688 £/year**
OPERATING COSTS	
Management	1 £/tonne
Cost of Management	**12,166 £/year**
Labour	2 £/tonne
Cost of Labour	**24,333 £/year**
Maintenance Contract	5 £/tonne
Cost of Maintenance & Spares	**60,831 £/year**
Cost of Electricity	80 £/MWh
Cost of Water	1 £/m3
Electricity Consumption	30 MWh/year
Water Consumption	0 m3/year
Cost of Utilities	**2,400 £/year**
Cost of Solid Biofertiliser Disposal	0 £/tonne
Cost of Liquid Biofertiliser Disposal	5 £/tonne
Solid Biofertiliser Production	1362 tonnes/year
Liquid Biofertiliser Production	10336 tonnes/year
Cost of Disposal of Biofertiliser	**51,680 £/year**
Waste Management License	2,000 £/year
Laboratory Costs	2,000 £/year
Collection Costs	2,420 £/year
Office Costs	0 £/year
Miscellaneous Costs	10,000 £/year
Other Operating Costs	**16,420 £/year**
Total Operating Cost	**167,830 £/year**
ECONOMIC ASSESSMENT	
Capital Cost	928,400 £
Income	432,688 £/year
Operating Cost	167,830 £/year
Net Income	264,858 £/year
Annual Discount Rate	7 %
Lifetime of Plant	15 years
Present Value of Net Income	2,412,305 £
Less Capital Cost	-928,400 £
NET PRESENT VALUE	**1,483,905 £**

Feedstock Conditioning & Storage

Mass of Organic Waste	233.3	tonnes/week
%DS of Organic Waste	9.4	% TS
%ODM of Organic Waste	78.5	% VS
Dry Solids of Organic Waste	22.0	tonnes/week
Organic Dry Matter of Organic Waste	17.3	tonnes/week
Mass of Process Water	0.0	tonnes/week
Mass of Digestate Liquor Recirculation	0.0	tonnes/week
%DS of Digestate Liquor Recirculation	0.0	% TS
%ODM of Digestate Liquor Recirculation	0.0	% VS
Dry Solids of Digestate Liquor Recirculation	0.0	tonnes/week
Organic Dry Matter of Digestate Liquor Recirculation	0.0	tonnes/week
% Organic Waste Rejected as Inert	0.0	%
Mass of Inert Rejects	0.0	tonnes/week
%DS of Inert Rejects	0	%
%ODM of Inert Rejects	0	%
Dry Solids of Inert Rejects	0.0	tonnes/week
Organic Dry Matter of Inert Rejects	0.0	tonnes/week
Mass of Digester Feedstock	233.3	tonnes/week
Dry Solids of Digester Feedstock	22.0	tonnes/week
Organic Dry Matter of Digester Feedstock	17.3	tonnes/week
Specific Gravity of Feedstock	1.04	tonnes/m3
Volume of Digester Feedstock	224.4	m3/week
Capacity of Conditioning Tank	35	m3
Storage Time Available in Conditioning Tank	1.1	days
Capacity of Raw Waste Buffer Tank	198	m3
Storage Time in Available in Raw Waste Buffer Tank	6.2	days

Anaerobic Digestion

Mass of Digester Feedstock	33.3	tonnes/day
Volume of Digester Feedstock	32.1	m3/day
%DS of Digester Feedstock	9.4	% TS
%ODM of Digester Feedstock	78.5	% VS
Dry Solids of Digester Feedstock	3.1	tonnes TS/day
Organic Dry Matter of Digester Feedstock	2.5	tonnes VS/day
Capacity of Digester	792	m3
Methane Production	634	m3 CH4/day
% Methane	60	% CH4
Volume of Biogas	1,057	m3/d
Specific Gravity of Biogas	1.21	kg/m3
Mass of Biogas	1,284	kg/d
Mass of Digester Output	32.0	tonnes/day
%DS of Digester Output	5.8	% TS
%ODM of Digester Output	63.7	% VS
Dry Solids of Digester Output	1.9	tonnes/day
Organic Dry Matter of Digester Output	1.2	tonnes/day
Specific Gravity of Digester Output	1.02	tonnes/m3
Volume of Digester Output	31.4	m3/day
Hydraulic Retention Time	**25**	**days**
%TS of Digester Feedstock	**9.4**	**% TS**
Specific Loading Rate	**3.1**	**kg VS/m3/day**
Biogas Production per day : Digester Capacity	**1.3**	**m3/d/m3**
Biogas Production : m3 Digester Feed	**33**	**m3/m3**
Biogas Production : Tonnes of Organic Waste	**32**	**m3/tonne**
Methane Production : Tonnes Organic Waste Organic Dry Matter	**257**	**m3/tonneODM**

Biogas		
Biogas Production	1,057	m3/day
Biogas Flow	44	m3/hour
% Methane	60	% CH4
Calorific Value of Biogas (LCV)	21.4	MJ/m3
Fuel Value of Biogas	22,651	MJ/day
Fuel Value of Biogas	262	kWf
Combined Heat & Power		
Fuel Value of Biogas	262	kWf
Electrical Efficiency	32.0	%
Thermal Efficiency	53.0	%
Electricity Output	84	kWe
Heat Output	139	kWth
Availability of CHP Unit	95	%
Annual Electricity Output	698	MWh/yr
Annual Heat Output	1,156	MWh/yr
Gas Boiler		
Fuel Value of Biogas	262	kWf
Thermal Efficiency	85.0	%
Heat Output	223	kWth
Gas Boiler Operating Time	5	%
Annual Heat Output	98	MWh/yr
Heat Requirement		
Volume of Digester Feedstock	32	m3/day
Temperature of Digester Feedstock	10	^{o}C
Temperature of Digester	37	^{o}C
Temperature of Outside Air	10	^{o}C
Heat Input to Digester Feedstock	3,626	MJ/day
Total Surface Area of Digester	398	m2
Thickness of Insulation	100	mm
Average Thermal Conductivity of Insulation	0.034	W/m.^{o}C
Digester Heat Loss	316	MJ/day
Total Digester Heat Requirement	3,942	MJ/day
Total Digester Heat Requirement	45.6	kWth
Volume of Pasteurisation Feedstock	31	m3/day
Temperature of Pasteurisation Feedstock	37	^{o}C
Temperature of Pasteurisation Tank	71	^{o}C
Temperature of Outside Air	10	^{o}C
Heat Input to Pasteurisation Feedstock	4,476	MJ/day
Total Surface Area of Pasteurisation Tank	71	m2
Thickness of Insulation	100	mm
Average Thermal Conductivity of Insulation	0.034	W/m.^{o}C
Pasteurisation Tank Heat Loss	127	MJ/day
Total Pasteurisation Heat Requirement	4,603	MJ/day
Total Pasteurisation Heat Requirement	53.3	kWth
Total Heat Requirement	8,544	MJ/day
Total Heat Requirement	866	MWh/yr
Electricity Balance		
Electricity Output	698	MWh/yr
% Parasitic Electricity	4	%
Electricity Consumption of Plant	30	MWh/yr
Net Electricity Output	**668**	**MWh/yr**
Heat Balance		
Heat Output	1,254	MWh/yr
% Parasitic Heat	69	%
Heat Consumption of Plant	866	MWh/yr
Net Heat Output	**388**	**MWh/yr**