Prepared for

Waikato/BOP Chicken Growers Group

Bioenergy Assessment

Scoping Study for Utilisation of Chicken Litter for Energy

By

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Executive Summary

This assessment scopes the potential opportunity for utilising chicken litter in a waste fuelled bioenergy plant in the greater Waikato area for the Waikato/BOP Chicken Growers Group.

The chicken litter, made up of dry shavings and chicken manure, is currently loaded into trucks for immediate transport off the chicken growers' sites. Litter is generally transported to farms where it is spread on pasture as fertiliser.

Fonterra has indicated that the environmental effects of the application of this and other raw effluent could have a detrimental effect on trade access and they may no longer take milk from farms that use litter as fertiliser. As a result the Waikato/BOP Growers Group (of chicken farmers) are investigating alternative methods of disposal of the litter.

This assessment was undertaken in order to provide a preliminary assessment of an alternative to the current disposal of chicken litter from chicken farms in the greater Waikato area. This alternative would use anaerobic biodigester technology to produce biogas, with the remaining product being available as a fertiliser.

A suitably sized anaerobic digester plant, assumed to be located at the Inghams chicken processing plant at Waitoa to both provide a centralised site and allow for appropriate material from the plant's waste streams to be added to the feedstock for the digester plant, is the main focus of this assessment.

The assessment assumes that the number of chicken farms participating will mean that there is a regular supply of chicken litter throughout the year and that this will allow for continuous digester operation.

Methane gas produced from a biodigester fuelled on chicken waste is a suitable fuel for boilers and it is assumed this gas would be piped to the Inghams chicken processing plant heat plant in preference to a lower value option of using the gas for electricity generation.

Although biodigester technology has been around for many years there are few international examples where chicken litter is processed in digesters. Internationally there are a greater number of digesters fuelled by farm stock waste (effluent), although the total number in this category is still very small, noting that the emphasis is on processing farm stock waste and that this is principally driven by environmental objectives. This assessment draws extensively on a December 2005 feasibility study for a biogas plant using chicken litter in Arizona.

While this assessment has shown that the production of biogas from chicken litter for this project is not currently able to pay the growers the current market price for chicken litter and still be economically viable, biogas production may become commercially viable under the scenario of a reduction in the current demand for chicken litter as fertiliser should Fonterra no longer take milk from farms that use chicken litter. Under such a scenario baseline returns of about $21.75/tonne for chicken litter to be used as feedstock for a biomass digester could represent the best available price. However, the bulk of revenue (approximately 70%) would come from the sale of a liquid fertiliser product. Under this, and other scenarios, the uncertainty over the market value of this liquid fertiliser produced by the digester would need to be reduced before a significant level of confidence could be attached to a digester operation.

These outcomes are based on the assumptions made and some of these assumptions may vary significantly as the project is progressed. These results however indicate that, given the level of confidence in the assumptions, further work on the use of digesters for converting chicken litter and broiler chicken processing waste to energy (and the associated by-products), is justified.

Contents

1 Introduction

The Waikato/BOP Chicken Growers Group has approached East Harbour Management Services to provide a preliminary assessment of the potential for a biogas digester project to assist with the disposal of chicken litter collected from chicken farms in the greater Waikato area.

This preliminary assessment outlines the potential for anaerobic digester or combustion technology to significantly reduce the volume of chicken litter and obtain a value product (biogas) in comparison to the current situation of spreading the untreated chicken litter on pasture land.

2 Project Outline

Project Description

Chicken growers in the greater Waikato area produce large quantities of chicken bedding litter, made up of dry shavings and chicken manure. Litter is disposed of by sale and generally transported to farms where it is spread on pasture as fertiliser. The current value for the litter is around $35/tonne of litter loaded onto trucks at the shed door.

Fonterra has indicated that the environmental effects of the application of this and other raw effluent could have a detrimental effect on trade access and they may no longer take milk from farms that use litter as fertiliser. As a result the Waikato/BOP Growers Group (of chicken farmers) are investigating alternative methods of disposal of the litter.

The chicken growers are investigating whether an alternative to selling the litter is that it be used as a feedstock for the production of energy by way of combustion or anaerobic digestion, with possible sale of the liquid fertiliser and humus by-products.

Note that, in this assessment:

- ***Waste*** is considered as by-product of a process which is unused (e.g. chicken litter is waste from rearing broiler chickens).
- ***Feedstock*** is considered as raw material (fuel) suitable for an anaerobic digestion process (e.g. chicken litter and water)
- ***Biogas*** (consisting of methane and carbon dioxide) is considered as the main product of the anaerobic digestion process.
- ***Substrate*** refers to the biological material within the digester and exiting the digester.
- ***Humus*** refers to the solid portion of the substrate by-product of the digestion process.
- ***Liquid Fertiliser*** refers to the liquid portion of the substrate by-product of the digestion process.

The growers have joined with their processor Inghams Enterprises (NZ) Pty Ltd (Inghams) who have a plant at Waitoa, to evaluate the chicken litter to energy opportunity. Inghams have a range of high moisture content process residues which could be mixed with the dry chicken litter to provide an optimal consistency feedstock for operation of an anaerobic digester.

The project is based on the assumption that chicken litter from a number of chicken growers would be collected and transported to an energy facility adjacent to the Inghams' plant.

The project is a scoping study to evaluate the opportunity with respect to undertaking a full feasibility investigation. The scoping study is based on readily available information and where necessary generic data from international literature. The scoping study will focus primarily on use of anaerobic technology but some consideration of combustion technology will be included.

3 Current Operations

Chicken growers

Chicken growers currently clean the litter in each growing shed out approximately every 60 days when chickens are moved out. The litter is loaded into trucks for immediate transport off site. Some growers clear the sheds themselves and load the trucks while others have the party that takes the litter away undertake the clearance and loading.

While there are a range of income gained from the sale of the litter for the purposes of this assessment it is assumed that the chicken grower receives $35/tonne on the truck.

Clearing of sheds is staggered so there is essentially a near continuous flow of litter from each farm. Clearing occurs throughout the year with breaks of only a few days between a clearance.

Inghams

The chickens from growers are processed at Inghams Waitoa chicken processing plant.

Inghams processing plant has a wide range of processing residues from the processing floor and from process sludges. The processing residues are used to make chicken meal. The sludge is presently collected into a sludge pond on site and periodically the solids dug out.

4 Project Assumptions

The scoping evaluation has been undertaken using the assumptions given below and in Table 1. The assumptions are intended as an indicative representation of the current understanding of the project, process and parameters.

Locality

For the purpose of evaluation the bio energy facility will be located adjacent to the Inghams Waitoa processing plant site (see attached map in Appendix 1 for location).The land is owned by Inghams and is held for possible future plant expansion.

Location on Site

The plant will be located within 500m of the sludge ponds on the Inghams Waitoa site (see attached map of site in Appendix 2). This is assumed to be an adequate balance of distance for litter storage from a food processing facility, and the distance to pump sludge.

Feedstock

The quantity of chicken litter available for conversion to energy was supplied by Radar O'Reilley and is attached as Appendix 3 along with processing plant sludge information from Muhannad Juma of Inghams.

It is assumed, for evaluation purposes, that the Inghams broiler sheds (approx 5000 tonne per annum of chicken litter) and only 75% (28) of the 37 chicken growers in the area will elect to provide litter to the energy facility The 28 largest chicken producers have been assumed to join the project. This results in approximately 36,000 tonnes of litter being delivered from chicken growers and Inghams to the energy facility each year.

The large number of litter suppliers and the 60 day cycle of chicken shed clearing means that the potential feedstock supply is uniform throughout the year. It is assumed that 125 tonnes/day of litter will be delivered five days a week, with 20 days a year allowance for public holidays when no delivery will occur.

Some storage will be needed to even out weekly humps and hollows of when litter comes available noting that there is minimal (if any) reduced operation during the Christmas New Year period. A storage capacity of 7 days delivery (880 tonnes) is assumed with a volume for storage required of 275 m^3.

It is assumed that process wastes from the Inghams processing plant would be used to help in achieving the optimal blend of feedstock for a digester. There are two streams of process residue; offal and chicken off-cuts, and sludge from the liquid effluent processing plant. For the purpose of this assessment it is assumed that the sludge only will be used to mix with the litter to assist in obtaining the optimal feedstock moisture content.

Digester Plant

An anaerobic mixed bed digester was used as the 'reference' plant for this assessment. This appears to be the most suitable type of digester for the type and quantity of feedstock and is also the type of digester identified in a December 2005 feasibility study for a biogas plant using chicken litter in Arizona[1] that this assessment extensively draws on.

Assuming:

- o an optimal digester design moisture content of 90%,
- o litter moisture content of 35%,
- o sludge moisture content of 80%, and
- o 100 tonnes/day ("dry" matter) of chicken litter processed

65 tonnes of Inghams sludge per week would be used in the digester and would need to be supplemented by a significant amount of water to achieve the optimal moisture content.

The assumed Project Parameters are given in Table 1

Table 1; Project Parameters (assumed)

Project Parameters Assumptions		
Item	**Units**	**Value**
Amount of chicken litter (tonnes pa)		36,000
Amount of processing plant sludge (tonnes pa)		3,380
Value of Chicken Litter on farm ($/tonne)		$101.70
Cycle time		60 days
Delivery Rate (5 days/week) tonnes/day		125
Storage Capacity for chicken litter (7 days)		257 cu metres
Capital Cost ($NZ million) -see below		6.17
Weighted Average cost of Capital (WACC)		10%
Biogas Sale Price ($/GJ)		$11
Liquid fertiliser Sale Price ($/Tonne)		$14.00
Solid fertiliser Sale Price ($/Tonne)		$7.50
NZ$/US$ exchange rate		0.60
Discount-lower NZ vs US material, labour etc cost		20%
Solids content of chicken litter		35%
Moisture content of chicken litter (CL)		65%
Moisture content of processing plant sludge		80%
Dilution ratio- solids/liquid (by volume)		85%
Additional water needed/tonne of CL	Tonnes	3.333
Biogas Yield (BY)	cu metres/tonne of feedstock	119
Calorific Value of Biogas (CV)	MJ/cu metre of biogas	23.0
Energy in Biogas	MJ/tonne	990
Direct Combustion Efficiency (Heat)		N/A
Gas used to heat digester		46%
Influent pumping energy		1%
Gas onsold		53%
Depreciation	Diminishing Value (DV)	6%
Project Life	Years	15

[1] The Ak-Chin Indian Community Biomass Feasibility Study Final Technical Report – December 2005

Type of Digester Plant

The main plant item is assumed for this assessment to be an anaerobic digester. The type of digester will be evaluated.

Figure 1 shows the main plant components.

Other plant and associated infrastructure on the site could include:

- Litter surge /storage capacity for incoming chicken litter sized to allow for normal variability in the week by week supply and a 7 day break in delivery. It is assumed that an open vented covered three sided shed into which trucks can dump litter on delivery, and a tractor can reclaim for feeding into the digester.
- A surge/storage tanks for incoming sludge from the chicken processing plant could be required at the energy facility site but for the purpose of this assessment it is assumed that the sludge could be pumped direct from the processing plant sludge pond.
- Surge bins/storage areas for digester plant residue "digester fertiliser". A storage capacity of 40 days is assumed.
- Any "scrubbers" to clean up the biogas to meet storage and end use requirements.
- Biogas storage. It is assumed that this will be an inflatable storage container.
- Pump and pipeline for extracting and transporting sludge from the processing plant sludge pond and the digester.
- Gas pipeline from the energy facility to the Inghams gas hot water boiler.
- Gas measuring meter.

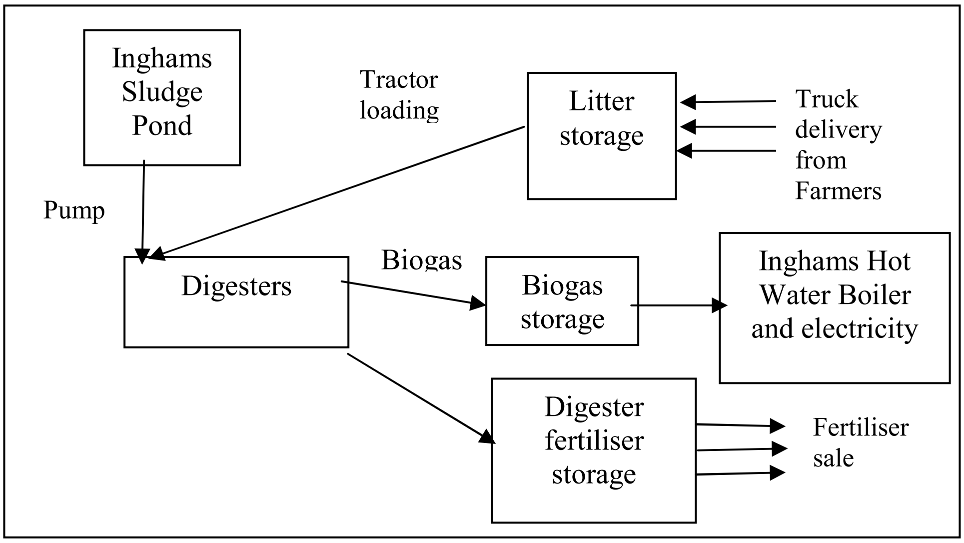

Figure 1: Plant Components

Digester Plant Operation

The energy facility will operate continuously throughout the year. An anaerobic digester requires continuous steady state operation for optimal biogas output. At least two digesters will be built so that in the event of maintenance requiring a digester close down the other digester will be able to continue operation.

It is assumed that two staff will be required to operate the plant. They will be operator maintainers with responsibilities to manage reception of litter, loading of digester with litter and sludge, delivery of gas and extraction and sale of fertiliser.

They may operate staggered and part overlapping hours to provide up to 12 hour on-site coverage. It is assumed that remote monitoring and control of the facility will allow the operators to monitor alarms when off-site. This assumption for this staffing arrangement will need to be confirmed with the OSH.

A third Inghams plant maintenance person will be trained to provide overlap and assistance in the event of illness and operator holidays.

Biogas output

The energy facility will produce biogas with an estimated 23 MJ/cu metre calorific value which will be piped to an inflatable storage container. The gas will be sold to Inghams and piped to the existing Inghams gas boiler. It is assumed that the Inghams boiler will have at least one existing gas inlet jet dedicated to biogas while remaining jets are retained for natural gas use.

Plant Layout

A schematic of a typical anaerobic digestion system is shown in Figure 2.

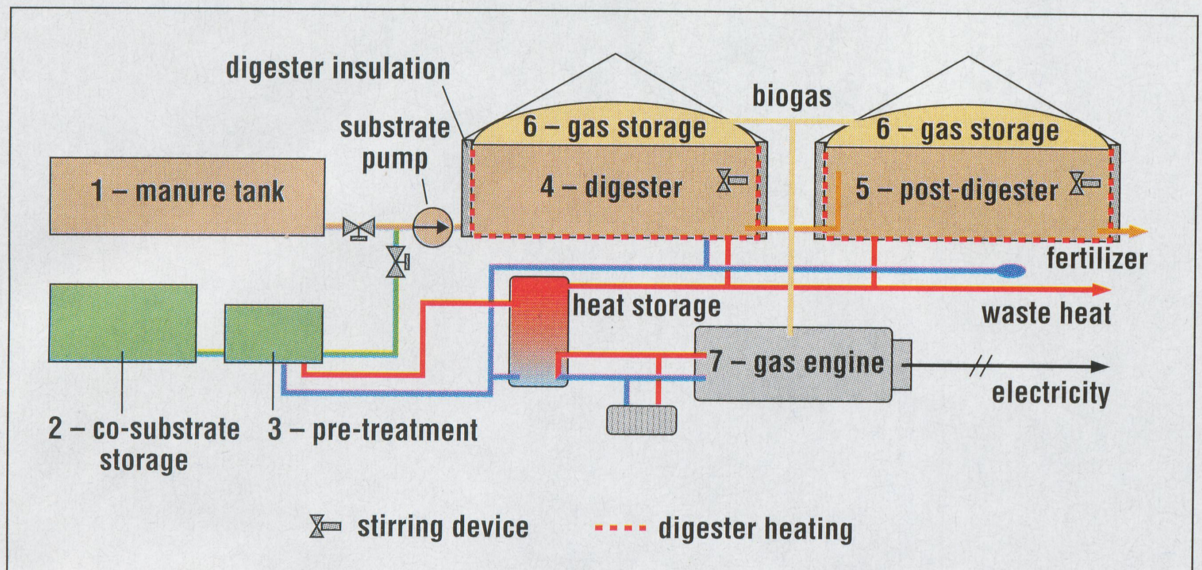

Figure2. Schematic of a typical anaerobic digestion system

Source: Renewable Energy World March-April 2004

Resource Consenting

The District Plan and Regional Plan provisions have still to be assessed in relation to any consents for the Inghams Waitoa site and establishing and operating a digester plant on the site. While parameters for any resource consent application have still to be determined, it is likely that effective effluent and water management along with odour will be issues that would require attention.

5 Commercial Parameters and Assumptions

Analysis Options

Project Option 1

Anaerobic Digester for chicken litter and process residues from the Inghams processing plant.

Project Option 2

A simple comparison of using the chicken litter in a combustor to produce hot water for supply to Inghams.

Revenue Assumptions

Revenue/expense stream for the operation of the plant includes payments made in relation to:

(a) the acceptance of chicken litter delivered to the plant,
(b) the uptake of sludge from the chicken processing plant as alternative disposal methods to current practices,
(c) the sale of methane fuel or energy (heat or electricity) from the plant, and
(d) the sale of both liquid fertiliser and solids from the effluent stream of the plant.

Capital Assumptions

The capital cost estimate is based on the estimate in the December 2005 Ak-Chin Indian Community Biomass Feasibility Study report for an anaerobic digester system of similar size using chicken litter from an egg ranch.

Operating and Maintenance (O & M) Assumptions

The operating and maintenance cost estimates are based on the estimates in a previous study carried out by East Harbour for an anaerobic digester system.

Financial Assumptions

- A 20 year analysis period, with sensitivities of 15 and 25 year periods
- 1.5% real rate of inflation
- 10% discount rate (after tax, real) with sensitivities of 8% and 12%
- 9% depreciation with sensitivity of 18%
- residual value = book value

Sensitivity Analysis

Sensitivity analysis of the following parameters will be undertaken:

- Quantity of litter available
- Calorific value/yield of biogas
- Sale price of biogas
- Yield and Sale price of liquid and solids fertilisers
- Capital costs
- Cost of capital (WACC)
- Operating and maintenance costs
- Project life
- Depreciation

6 Anaerobic Digestion – Option 1

6.1 Anaerobic Digestion Plant

An anaerobic digester is essentially a heated tank into which a wet organic substrate is fed. Oxygen is excluded to allow anaerobic bacteria to liquefy the organic compounds in the mixture and then convert the resulting simple organic acids into a methane rich biogas. Anaerobic conditions allow methane producing bacteria to flourish while inhibiting those that produce foul odours. The liquid residue is a nutrient rich fertiliser which, having lost much of its odour, can be used directly on land. Insoluble compounds may collect in the digester or pass through it unchanged. The undigested humus has not lost any nutrients and is suitable for storage and then land application, or for sale as stock feed (where appropriate) or as compost or soil conditioner.

The anaerobic digestion process does not produce any "waste" as all outputs have high value and can be used.

As anaerobic digesters rely on the action of micro organisms, which are temperamental to temperature fluctuations, inappropriate loading rates and retention times, pressure, agitation and contaminants within the feedstock, the digester requires good design and operational management. Modern digester technologies assist achievement of good bacterial growth through careful monitoring and control of digestion conditions. Inappropriate management will significantly affect the biogas yield.

The biodigester is usually heated to provide optimal conditions for bacterial growth.

6.2 Status of Digester Applications Internationally

Anaerobic digester technology has achieved significant advances over the last 25 years. This is largely due to the development of industry capability through providing solutions to environmental issues facing primary producers (dairy and pig farmer effluent processing), and sewage treatment. While the technology has advanced there has been a notable absence of other applications e.g. food and vegetable waste, using the technology. In fact world wide there are few specific reference examples (other than of dairy farm applications) that this assessment could refer to.

In New Zealand, large sewage treatment waste water processing facilities[2] have led the way in uptake of anaerobic digestion technology, using biogas produced from the processed waste to power the treatment plant, and with excess energy exported into the electricity network.

At a smaller scale, several New Zealand dairy farms have been trialling anaerobic digesters to process effluent into low-pathogen fertiliser, and to generate electricity. An example of this is the dairy farm digester project at Orini, northeast of Hamilton. Three digester modules (stainless steel construction, see Figure 3) convert effluent from a 2000 cow feed-pad and dairy into biogas, which in turn fuels a 6-cylinder engine to generate up to 53kVA of electricity for seven hours a day (plant factor 0.29).

[2] North Shore City Water Treatment Plant, Christchurch Bromley Wastewater Plant and Hamilton Pukete Wastewater Treatment Plant.

Figure 3. Two of Three ISE Digesters Producing Bacteria-Free Fertiliser and Methane Gas at Orini Downs Dairy Farm

6.2.1 Biogas Output

The yield of biogas varies significantly from one feedstock to another. This is due to the percentage of dry matter (DM or total solids), and in turn, the percentage of volatile solids (VS) within the feedstock.

For the purposes of this assessment, a gross biogas yield of $40m^3$/tonne of feedstock has been used which is in line with international data (Figure 4). A sensitivity of ±20% is used in the economic analysis, which takes into account the significant variation in net saleable biogas yields quoted by both equipment suppliers and literature.

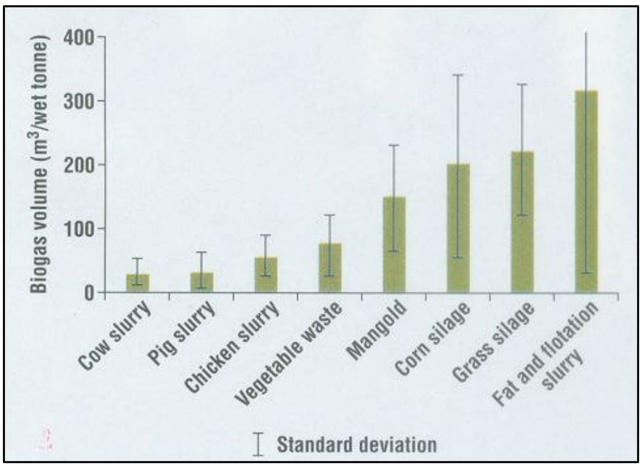

Figure 4. Average Biogas Yield per Tonne of Wet Waste for Some Possible Substrates (Showing Variance)

6.2.2 Gas Treatment

Biogas typically contains significant amounts of water, siloxane (silicate compounds) and CO_2. Water may have to be removed prior to compression and supply of the gas for cogeneration use. It may not have to be removed for direct use of gas in a boiler.

CO_2 may be problematic due to it mixing with water in the gas and forming carbonic acid which is detrimental to most process equipment. Several CO_2 treatment options are available if needed

6.2.3 Direct Use of Gas

Biogas can be used directly in boilers for heating water. Because of its low calorific value, the volumes used are more than for natural gas, so pipe sizes have to be larger and pressurisation is required for transmission over long distances (i.e. 2 km).

Biogas does not require specific treatment if used directly in boilers but would require very specific treatment if it were to be reticulated for other uses including residential use. For the purposes of this assessment, it is assumed that biogas would only be used directly into existing boiler plant and thus no treatment is required.

Biogas calorific values will fluctuate according to feedstock and digester operation. As it is assumed that security of (gas) supply is provided by natural gas, storage tanks need not be conservatively sized when looking to ensure some uniformity of gas quality by mixing.

Boiler controls should be such that they are able to deal with fluctuations in fuel quality.

This assessment also assumes that the fuel can be used in the existing Inghams boiler thus reducing the need for additional capital expenditure.

6.2.4 Cogeneration

Biogas may also be used in gas turbines or gas engines for the production of electricity after only minimal treatment for removal of contaminants such as water and hydrogen sulphide. An advantage of gas engines is that they are also efficient producers of heat so are good for cogeneration applications. A gas turbine however requires a heat recovery boiler in order to recover the heat component.

It is assumed that the biogas will result in Inghams being able to avoid the purchase of the equivalent thermal quantity of natural gas. On this basis it is almost certain that the biogas has an intrinsically greater value if used in direct firing than cogeneration. Accordingly, this assessment does not include a cogeneration option at this stage.

Cogeneration requires the input of additional heat plant and an electricity generator at an estimated expenditure of $1 million.

6.2.5 Fertiliser or Stock Feed

The solid waste and liquor removed from the biodigester after processing should be suitable as a very good fertiliser and can be used directly or dried for use as compost. As the energy from a digester located at the Inghams plant will probably be used for direct heat plant, it is likely that the fertiliser will be sold in liquid form. . The growers group has provided the results of an analysis of a sample of the proposed feedstock by Hill Laboratories and this gives a good indication of the likely nutrient content of the liquid fertiliser and its potential value. Once the make-up of the liquid fertiliser is better understood, its suitability for application on farms may be evaluated.

7 Combustor Technology Applications – Option 2

7.1 Combustor Technology

7.1.1 Direct Combustion

Chicken litter has, due to its make-up and moisture content, a significant calorific value. It can therefore be used directly as a fuel for heating or producing electricity.

Direct combustion involves the burning of a fuel, such as chicken litter with excess air, producing hot flue gases that are used to produce steam in the heat exchange sections of boilers.

Large Scale Systems

Chicken litter has been used in many countries, mainly in heat production. A British company, Fibrowatt, operates four power stations in Britain, is planning one in the Netherlands, and is proposing several facilities to be built in the United States. The Fibrowatt Thetford poultry litter power plant is located at the centre of England's poultry producing region and consumes 420,000 tons of litter each year and has a capacity of 38.5 MW. There have also been a number of plant failures.

However, many of these power plants have suffered production interruptions due to difficulties related to "difficult" fuel even though they have been specially designed to burn chicken litter[3].

The main problem has been the very aggressive and sticky fly ash dust, which has blocked flue gas paths between the heating surface tubes of the boiler, in particular in cold areas in the economizer and air preheater. As a consequence, the boiler has to be shut down and cleaned, often many times a year.

Other disadvantages of poultry litter as fuel include the high nitrogen content and corrosion by the flue gases. The ash however has value as a fertiliser.

Small Scale Systems

At present there are no small scale systems commercially available to generate heat from poultry manure. Most research and product development for small scale use of poultry manure have focused on gasification systems. Direct combustion for generation of heat has not been studied extensively.

Several hurdles stand in the way of developing small scale systems. These include a hassle factor (natural gas is easier to use), economics, technical viability, ash management, and environmental regulations (emissions).

7.1.2 Co-Firing

Cofiring is the simultaneous combustion of a supplementary fuel, such as manure, with a base fuel, such as wood or coal. A number of trials cofiring chicken litter (and other biomass and waste materials) with coal have been carried out overseas particularly in Holland and in large power stations.

Combustion problems can result from the high phosphorus content of poultry litter. If burned at the elevated temperatures of an incinerator, the litter releases phosphorus, which forms phosphate salts and phosphoric acid. Both of these chemicals react with metal and therefore can cause deterioration and fouling in the boiler. Trials in Holland suggest that there could be an optimum chicken litter:coal blend to reduce the adverse effects[4].

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[3] "Road to Rot", by Carolyn Fry, Power Engineer June 200
[4] http://www.ecn.nl/docs/library/report/2004/c04069.pdf

Fuel handling and storage systems form the bulk of the capital expenditure required to convert to cofiring.

Other effects of cofiring biomass with coal are reduced burnout, a reduction in ash quality (if it is used for other purposes) and reduced heat transfer in the boiler[5].

7.2 Gasification

Pyrolytic Steam Reforming Gasification (PSRG) is an emerging gasification technology that can extract methane gas from carbonaceous materials and produce a benign ash that retains some the material's original fertiliser value.

This technology using a patented process by Carbon Conversion Technologies, Inc. (CCT) Gasification Conversion System (GCS) was considered as one of the options for the Ak-Chin Indian community[6] to utilise their chicken litter waste.

PSRG requires biomass feedstocks having approximately 40% moisture content to provide the steam necessary for the process.

32,800 tons at 70% moisture of raw chicken litter was available from the Ak-Chin Indian community farm. This reduced to 18,100 tons or 55 tons/day (at 40% moisture) as feedstock to the gasifier. Electrical output from the plant was 1.36 MW producing 10.1 GWh per year. The cost of producing this electricity was approximately US0.095/kWh which did not meet the required financial return. Addition of another 70 tons/day of equivalent biomass feedstock was required to make the project economic.

7.3 Conclusion on Use of Combustor Technology

There are a number of factors which make combustor technologies using chicken litter as a fuel difficult to implement on a small scale. Theses include fuel storage and handling, corrosion and fouling on heat transfer surfaces and emissions. Plant is relatively expensive in small sizes and the ash is less valuable as a fertiliser because of the loss of the nitrogen component.

Hence combustor technology is less suitable and less economic than anaerobic digester technology.

8 Digester Investment Economics

8.1 Cost Assumptions

The assessment has identified that the use of anaerobic digester technology is in its infancy and as a result the data used has had to be adopted from international digester equipment suppliers and international applications. As well as using information from the Ak-Chin biogas feasibility report referred to earlier in this assessment, information provided by NZ based suppliers of digester equipment has been taken in to account.

8.1.1 Methodology of Economic Assessment

The economic assessment was carried out with the assumptions for a number of parameters being used as inputs to "solve for" the payment to growers for chicken litter ex farm ($/tonne) as the output of the modelling.

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[5] Optimal Co-Combustion of Biomass/Waste Fuels in Pulverized Fuel Firings, (publication by the Energy Technology Section at the TU Delft)
[6] The Ak-Chin Indian Community Biomass Feasibility Study Final Technical Report – December 2005

Once the baseline break-even value for chicken litter payments to growers was established a number of sensitivities to the input parameters were applied, giving a range of payment to growers. The results of these sensitivity analyses are depicted in Figure 3.

8.1.2 Capital Expenditure

The capital investment required for digester equipment is based on the Ak-Chin December 2005 estimates and includes estimates for:

- Feedstock Storage and Processing
- Gas Pipeline
- Digester Substrate Separation
- Site Services and a Staff Building
- Consents

8.1.3 Operational Expenses

- Feedstock Storage and Processing
- Gas Pipeline
- Digester Substrate Separation
- Site Services and a Staff Building

8.1.4 Potential Revenue Streams

A biogas processing plant in the Greater Waikato area has potential to gather revenue through several channels:

- Biogas
- Fertiliser/Stock feed
- Possibly Carbon Credits (Promissory Notes or similar)

8.1.5 Biogas Revenue

The estimated quantity of biogas produced by a digester plant for chicken litter at Inghams (Waitoa) is 11,750 cubic metres/day, of which an estimated 5,400 cubic metres/day is used in heating the digester liquid to maintain its temperature in the operating range. This results in a net estimated 6,350 cubic metres/day available for sale.

It is assumed that:

- the fuel demand of the Inghams processing plant at the Waitoa site exceeds this figure, and
- the net gas available will be sold to Inghams processing plant at the Waitoa site at an assumed price of $11/GJ.

8.1.6 By-Product (Liquid Fertiliser / Humus) Revenue

By-products of digester operation (sludge or substrate) are separated into liquid and solid pulp. These are considered (at this stage) as a high-nutrition liquid fertiliser and dry matter suitable for application to land.

The value of the high-nutrition liquid fertiliser is roughly estimated at about $14 per tonne of liquid by comparison with other fertiliser available on the market currently. Turning this value into a sale price is speculative at this stage because the product has not been placed on the market. This would rank as the highest and most critical (providing approximately 73% of the total revenue) uncertainty of the opportunity.

The value of the solid by-product of anaerobic digestion (humus) is roughly estimated at between $5 and $10 per tonne of equivalent dry matter. A "dry-tonnage" basis for pricing is due to the digesters requirement for operating with a specific dry matter content, rather than the variable feedstock wet tonnage supplied to the digester.

8.1.7 Cogeneration

Because of the need for additional capital expenditure, cogeneration of heat and electricity is assumed to provide a lower value product than if all biogas is used for direct heat and has not been included in the modelling.

8.1.8 Carbon Credits

Biogas (methane and carbon dioxide) is a greenhouse gas, of which the methane component has 21 times the effect of CO_2. A biogas plant has potential to have a net greenhouse gas benefit. Government promissory notes may add further value to this project. As this stage any revenue is speculative and is therefore considered only as a sensitivity at this stage of investigation.

8.1.9 Payment to Growers for Chicken Litter

The output of the baseline economic assessment indicates that the payment to growers for chicken litter ex farm would be about $21.75/tonne calculated in terms of baseline assumptions provided in Section 4

It is clear from the assessment that the expectation of a $35/tonne payment for chicken litter will not be achieved by a significant margin under any assumptions covered in this assessment.

8.1.10 Sensitivity Analysis

The sensitivity of the payment to growers for chicken litter to a range of variations to the base assumptions is calculated and shown in Figure 5

The variations to the baseline assumptions are shown in Table 2

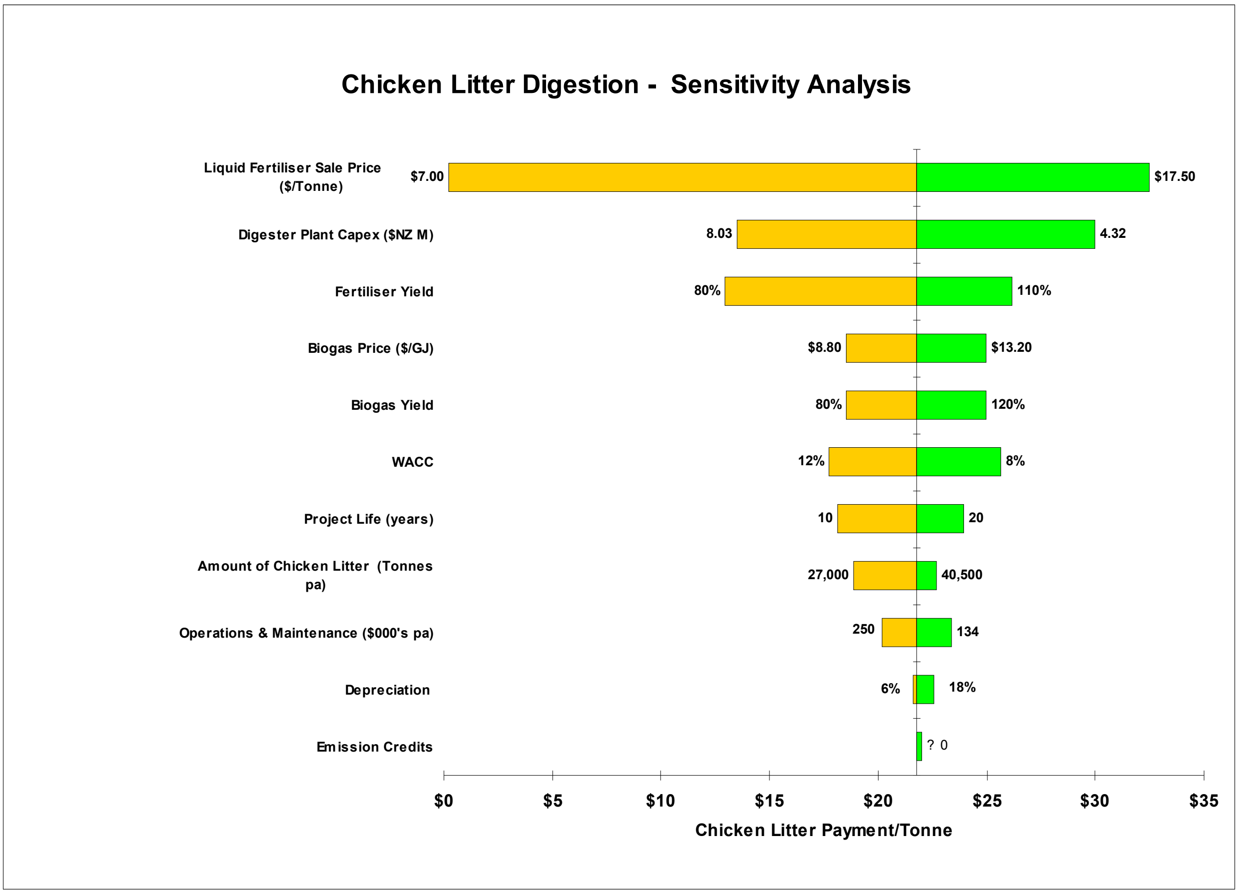

Figure 5. Sensitivity Analysis of Return to Chicken Litter Suppliers.

Table 2 Variations to Baseline Assumptions Used for Sensitivity Analysis.

Assumptions/Sensitivities				
		Input Values		
Input Variable	**Low**	**Base**	**High**	
Liquid Fertiliser Sale Price ($/T	$7.00	$14.00	$17.50	-50%/+25%
Digester Plant Capex ($NZ M)	8.03	6,174	4.32	+/-30%
Fertiliser Yield	80%	100%	110%	-20/+10%
Biogas Price ($/GJ)	$8.80	$11.00	$13.20	-/+20%
Biogas Yield	80%	100%	120%	-/+20%
WACC	12%	10%	8%	
Project Life (years)	10	15	20	
Amount of Chicken Litter (Tonnes pa)	27,000	36,000	40,500	+12.5/-25%
Operations & Maintenance ($000's pa)	250	192	134	+/-30%
Depreciation	6%	9%	18%	
Emission Credits	0	0	?	

8.2 Risk

Based on the probabilities and consequences outlined, a ranking of significant risks related to the operation of a biogas plant in the Greater Waikato area is summarised in Table 3.

Table 3. Summary of Foremost Chicken Litter Biogas Plant Risks.

Risk Area
Market and Value for Liquid Fertiliser
Market and Value for Biogas
Capital Cost of Digester Plant
Conversion of Feedstock into Biogas and By-Products
Operational Cost of Digester Plant
Feedstock Homogeneity and Supply Availability

The success of a biogas plant in the Greater Waikato area will be dependent on:

- Prior to a decision to invest; product (biogas and fertiliser) sales and plant costs and performance require the most attention from a risk management perspective.
- Once a decision to invest is made and the plant is installed and commissioned, feedstock related processes and correct operation of the plant become the prime areas for attention from a risk management perspective.

9 Comment and Forward Programme

This assessment has identified uncertainties in the project parameters that in some cases are significant or have a major effect on the project outcomes, lead to a corresponding uncertain confidence level in the results.

It is clear from the assessment that, on the basis of the assumptions made about a number of parameters, the expectation of a $35/tonne payment for chicken litter will not be achieved by a significant margin. This outcome is most affected by the sale price assumption for the liquid fertiliser by-product.

At first glance this suggests that the opportunity be shelved, except that the initiative taken by the growers group to commission this assessment reflected the issue of Fonterra possibly moving at some time to not accept milk from farms where chicken litter was spread on the pasture.

Should Fonterra make such a decision, the value of chicken litter is likely to be adversely affected to an extent that the price that would make a biogas development economic may then become the best return available. If the growers group considers that this scenario is likely to happen in the reasonably near future then it is suggested that a limited number of specific tasks that would reduce significant uncertainties arising from this assessment are carried out in the short term.

A study of Figure 5 indicates that, with a liquid fertiliser sale price that is 25% above the assumed base level (for this assessment) of $14/tonne, forecast chicken litter payments would be approaching the $35/tonne reference level and that a greater increase in sale price could lift returns above this reference level. Figure 6 shows an approach to the relationship between the chicken litter value when sold "as is, and the liquid fertiliser value. The "tonnage ratio" derives the value of the liquid fertiliser from the chicken litter value using the (inverse) ratio of the tonnage of the liquid (fertiliser) by-product to the tonnage of the chicken litter feedstock. This indicates that, for chicken litter values between $35 per tonne and $45 per tonne, the liquid fertiliser value could be between $11.5/tonne and $14.75/tonne.

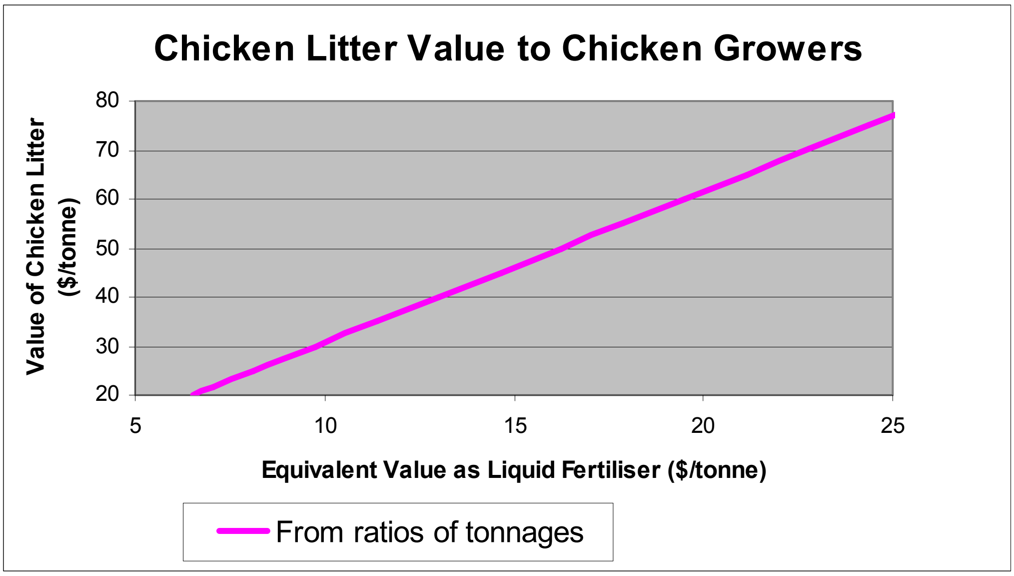

Figure 6. Relationship between Chicken Litter and Liquid Fertiliser Values.

While there may be significant uncertainty that the liquid fertiliser could command prices up to the $17.50/tonne at the upper end of the sensitivity range shown in Figure 5 and $20/tonne needed to return a $40/tonne price for the purchase of chicken litter, a preliminary assessment of the value of the chicken litter based on the Hill Laboratories chemical analysis and costs using regression analyses of the chemical content of commercial fertilizers is approximately $137/tonne dry and $114/tonne with 17% moisture.

Applying the comments made on the bottom of the Hill Laboratories analysis (as provided to East Harbour by the chicken growers group on 14 December 2006) that the actual nutrient content of the chicken litter is the equivalent of 1334 kg of urea plus 538 kg of 14% potassium superphosphate gives the value of the chicken litter of approximately $185/t. The degree of dilution will be a key factor in determining value of the liquid fertiliser by-product.

These aspects of liquid fertiliser value warrant further evaluation beyond this preliminary assessment stage.

The apparent disparity between the values shown in Figure 6 ($13/tonne of liquid fertiliser equating to $40/tonne of chicken litter) and the sensitivity analysis in Figure 5 identifying that the return to the chicken growers from a waste-to-energy plant selling the liquid fertiliser by-product at $13/tonne would be lees than $14/tonne of chicken litter is an indication that the waste-to-energy aspect of the digester operation is not. self supporting financially and would rely on liquid fertiliser sales.

Figure 5 also provides a view of the significant factors where more information will lead to a reduction in financial uncertainty. These are:

- Liquid Fertiliser
  Determining the commercial attractiveness of the liquid fertiliser by-product of the production of biogas by the digester and hence revenue returns from that product. There are four initial tasks associated with this:
  - gaining a very good understanding of the chemical and physical properties of the liquid by-product that can be used as fertiliser
  - determining the yield of this by-product
  - identifying the value of the by-product as liquid fertiliser

    - investigating market opportunities for this by-product. (Would the market prefer a drier product?)
    - Identifying barriers to commercial uptake of the liquid fertiliser.
- Energy Supply
  Identifying energy supply values for local demand and possible energy demand changes (5 year and 10 year time horizons) and determining that using biogas for direct heating is the best use (economically and environmentally).
- Gas Demand
  Confirming that the Inghams' plant can and will take and use the biogas at the quantities and quality levels associated with the digester plant at a price that is within or above the assumed price band.
- Ensuring that sufficient quantities of water to achieve the required dilution of chicken litter will be available, and determining the monetary and other costs of accessing, using and disposing of that water.
- Assessing the likelihood of the members (of the growers group) committing to using the bio-digester and determining a preliminary size of a biodigester system.
- Evaluating waste-to-energy plant options to ensure that the technology, capital and operational costs for a digester plant and its ancillaries in a New Zealand (Waikato) setting provide the optimal economics for waste-to-energy plant for this project.

Appendix A – Locality of Inghams Site

Appendix B - Inghams Processing Plant Map