BROILER MANAGEMENT & COST REDUCTION USING RENEWABLE ENERGY

A report for

NUFFIELD AUSTRALIA FARMING SCHOLARS

By Guy Hebblewhite

2013 Nuffield Scholar

December 2014

Nuffield Australia Project No 1315

Sponsored by:

RURAL INDUSTRIES Research & Development Corporation

© 2013 Nuffield Australia.
All rights reserved.

This publication has been prepared in good faith on the basis of information available at the date of publication without any independent verification. Nuffield Australia does not guarantee or warrant the accuracy, reliability, completeness or currency of the information in this publication nor its usefulness in achieving any purpose.

Readers are responsible for assessing the relevance and accuracy of the content of this publication. Nuffield Australia will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

Products may be identified by proprietary or trade names to help readers identify particular types of products but this is not, and is not intended to be, an endorsement or recommendation of any product or manufacturer referred to. Other products may perform as well or better than those specifically referred to.

This publication is copyright. However, Nuffield Australia encourages wide dissemination of its research, providing the organisation is clearly acknowledged. For any enquiries concerning reproduction or acknowledgement contact the Publications Manager on ph: (03) 54800755 .

Scholar Contact Details

Guy Hebblewhite
Countryside Farming Trust
“Moana” 106 Rushes Ck Rd
Tamworth 2340

Phone: 0432 121 450
Email: guy@puremanure.com.au

In submitting this report, the Scholar has agreed to Nuffield Australia publishing this material in its edited form.

NUFFIELD AUSTRALIA Contact Details

Telephone: (03) 54800755
Facsimile: (03) 54800233
Mobile: 0412696076
Email: enquiries@nuffield.com.au
PO Box 586 Moama NSW 2731

Executive Summary

- Today's broiler farmers face increasing energy costs eroding profitability.

- Renewable energy technology, other than solar photovoltaic (PV), does not exist in the Australian broiler industry.

- Biomass combustion is a commonly used renewable energy technology of converting biomass (litter) to heat.

- Heat energy is used to turn water into steam which can be used in the creation of electricity or as a transportable form of heat.

- Anaerobic digestion: microorganisms break down organic material (litter/corn silage) in the absence of oxygen. One of the end products is biogas.

- Biogas can be combusted to generate electricity and heat or can be processed into renewable natural gas and transportation fuels.

- Renewable Energy will be a powerful tool to assist broiler farmers lower energy costs in the future whilst maintaining environmental sustainability through possessing the lowest carbon footprint of any protein produced.

- New technologies exist for farmers to improve meat chicken average live weight using less feed.

- Overseas welfare standards will continue to influence how Australian farmers grow their chickens to meet consumer's expectations.

Contents

Index of Figures

Foreword

Our property “Moana” is a broiler farm that sits 40km from Tamworth, NSW. Along with our valued staff, my wife Genene and I and our three kids Tom (9), Jake (8) and Bonnie (5), run the property. It houses 450,000 day olds in 8 sheds of 50mm cool room panel construction. The farm broods day-old chickens using space ray heaters driven by a Fancom controller and has 10 tunnel ventilation fans per shed. Farm machinery is operated with diesel.

Electricity and gas consumption (usage) has increased significantly over the last 7 years. The main cost increase has been the price per unit for both types of energy. Together they comprise over 20% of farm operating costs.

On Moana, electricity prices (c/KWhr) have risen 27.6% since 2011/12. Bedding materials such as shavings and sawdust continue to climb to levels which will quickly make them an unviable alternative. Re-use of litter through multi-batching (processor restrictions often prohibit) offers the most viable option.

Inputs used each year on Moana are:

Water	60ML
Feed	12,000 tonnes
Electricity	600,000 kw
Bedding	6,500m3 of shavings (or straw)
Gas	130,000l (LPG)

Production per year:

Chickens	2.4 M
Meat	6.0 M kilos
Manure	10,000m3 (5,000 tonnes)
Employment	3 salaried staff, casuals and contract labour

Acknowledgements

I would like to acknowledge the following people and organisations for their support. Without it, I would not have had this opportunity.

To my wife Genene and children Tom, Jake and Bonnie. Thanks for your understanding and patience whilst I have been travelling and at times, all consumed with the Nuffield experience.

Jim Geltch and the Nuffield Board for having the confidence in me to be worthy of a Nuffield Scholarship.

My sponsor RIRDC – it was a privilege to be sponsored by them.

To the numerous people who hosted, fed, housed, interpreted and guided me throughout my travels.

To my fellow Nuffield Scholars on our Global Focus Tour group. To Sophie Stanley, Natasha King, Jodie Redcliffe, Kara Knudsen and Mathew Ipsen, thanks for the laughs and a lifetime of memories.

And finally to Rob Nichols (Nuffield scholar, 2008) for graciously presenting my Nuffield tie at our awards ceremony and for opening up his business “Nichols Poultry” for Genene and I to go away and digest.

Abbreviations

ACMF	Australian Chicken Meat Federation
AD	Anaerobic Digestion
CEFC	Clean Energy Finance Corporation
FBC	Fluidised Bed Combustion
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development (commonly known as the World Agriculture Report.)
MW	Mega Watt (1 million watts of energy)

Objectives

Australian chicken meat farmers are wanting to reduce costs associated with their operations and at the same time improve overall efficiency.

Utilising litter in an energy production system via combustion or anaerobic digestion will be examined as a way of generating renewable energy to help reduce these costs.

The objective of this report is to:

- Summarise visits to different parts of the world where these technologies were in use with a view to identifying the opportunities of implementing such technologies.
- Identify suitable production technologies that would improve meat chicken management overall.
- Make recommendations to the industry.

Chapter 1: Introduction

The Australian chicken meat industry plays an integral role in Australian agriculture and the broader economy, with the industry conservatively estimating that consumers currently spent $5.6 billion per annum on chicken meat in supermarkets, fast food outlets, specialty shops and restaurants. The industry is also one of the largest customers of Australia's grains industry, purchasing over 5% of all grains produced.

Chicken meat is an affordable and low fat source of protein enjoyed by families across the country. It is more popular than beef and has become increasingly popular in recent times. Demand for free range chicken has grown significantly. Seven years ago free range chicken could most accurately be described as a cottage industry. In a relatively short period of time it has grown to be around 20% of the total market. The primary reasons for purchasing chicken, as identified by consumers, show that chicken is:

- popular in the household, especially amongst children
- versatile
- healthy, and
- good value for money (Brunton, 2009).

The by-product of this popular white meat, poultry litter, has been traditionally spread on land, due to its relatively low cost to primary producers. More stringent legislation controlling land spreading of litter and the increased costs of energy (electricity and LPG) have caused chicken farmers to look at extracting additional value from their litter in the form of energy. Technologies for extracting energy from litter and other organic by-products exist in various forms around the world. Renewable energy in the form of anaerobic digestion or biomass (litter combustion) has the potential to be applied to the Australian chicken meat industry.

Globally

Over the past 50 years, global meat production has almost quadrupled from 78 million tonnes in 1963 to a current total of 308 million tonnes per year. The IAASTD (2008) predicts that this trend will continue, especially because the growing urban middle classes in China and other emerging economies will adapt to the so-called western diet of people in North America and Europe with its burgers and steaks.

On average, every person on Earth currently consumes 42.9 kilograms of meat per year. This figure includes babies and adults, meat eaters and vegetarians alike. In general, men eat more meat than women. In the European Union (EU), meat consumption has stagnated recently; there are also a growing number of vegetarians and vegans. The main type of meat consumed has switched from beef to poultry. The favourite meat of the average European, however, is pork. The Chinese also share this appetite for pork. Per capita, meat consumption in China has increased six-fold over the past 40 years. Since the population almost doubled to 1.3 billion people over the same period, global demand for meat and animal feed has exploded.

There are billions of farm animals worldwide. In 2013, the cattle population reached 1,494 million animals, up 54% from 1963. The number of chickens grown for human consumption increased from 4.1 billion to 21.7 billion between 1963 and 2013. During the same period, the pig population grew by 114% to reach 977 million head (IAASTD, 2008).

The Australian Chicken Meat industry today produces 660 million birds per year. This is forecast to grow at between 3-5% per year (ACMF, 2015). In contrast the USA is 15 times larger producing nine billion meat chickens per year.

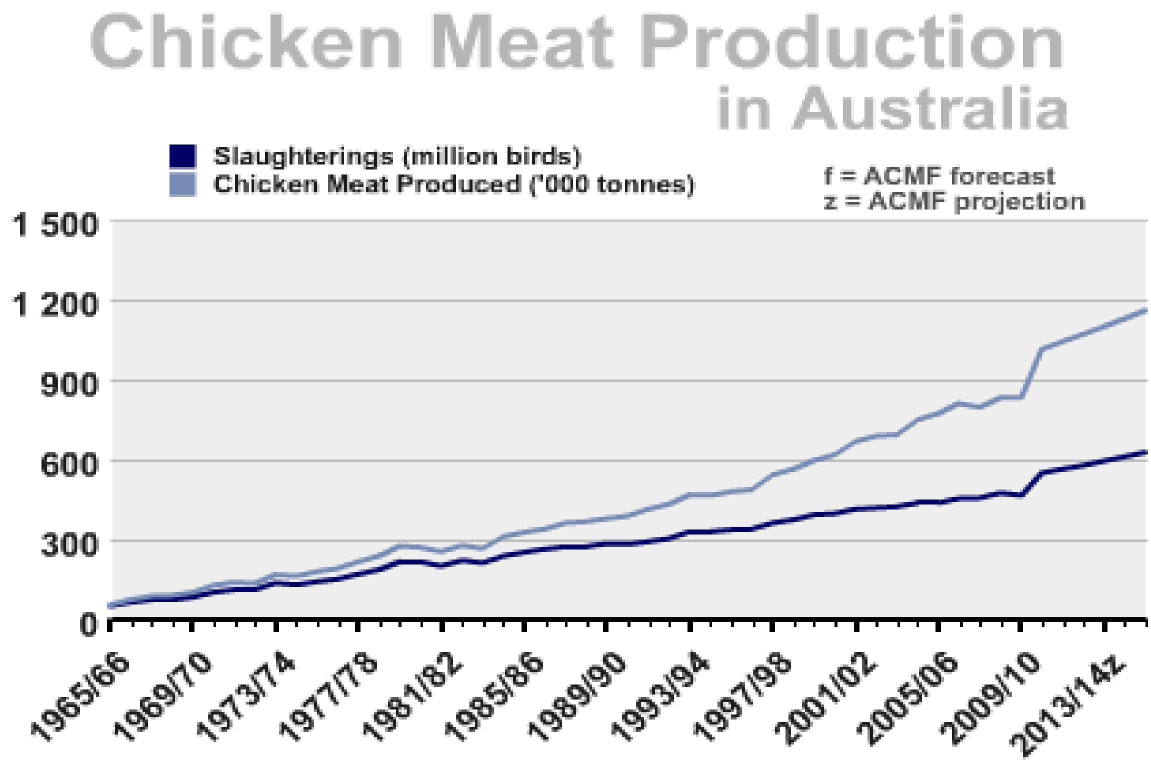

Figure 1: Chicken meat production in Australia (ACMF, 2015).

Chapter 2: Renewable energy insights

The energy requirement to produce chicken meat has changed over the last 15 years due to a change in shedding from conventional (natural ventilation) to tunnel ventilation. Tunnel ventilation requires fans to pull air through the shed to meet temperature requirements. This is also coupled with an increase in growth rate of the bird through genetic selection.

The cost of growing broiler chickens has risen dramatically over the last seven years. Chicken meat farmers need to avail themselves to different technologies that will reduce their costs and at the same time maintain farm performance efficiencies. The desire to innovate is there so long as the fine line between who receives the benefit of the cost reduction is understood – the farmer, the processor, the consumer or the bank who is usually the biggest shareholder.

It is suggested (Domgas, 2012) that the price of electricity will double in the next ten years so systems need to be investigated now that will enable farmers to carry on with stable profit margins into the future. The chicken meat industry is conscious of its environmental impacts, particularly through improved management of waste by-products such as litter. Litter is indeed seen as a valuable soil conditioner in most parts of the world and in Australia.

Litter is the largest by-product produced annually and is valued by other vegetable, grain and livestock farmers. The conversion of this waste into energy through anaerobic digestion, internationally, has seen rapid expansion of research and development in other various chemical, biochemical and thermal processes.

Fundamentally, the support of governments in other parts of the world in regions where waste-to-energy plants have been established has clearly incentivised farmers to act.

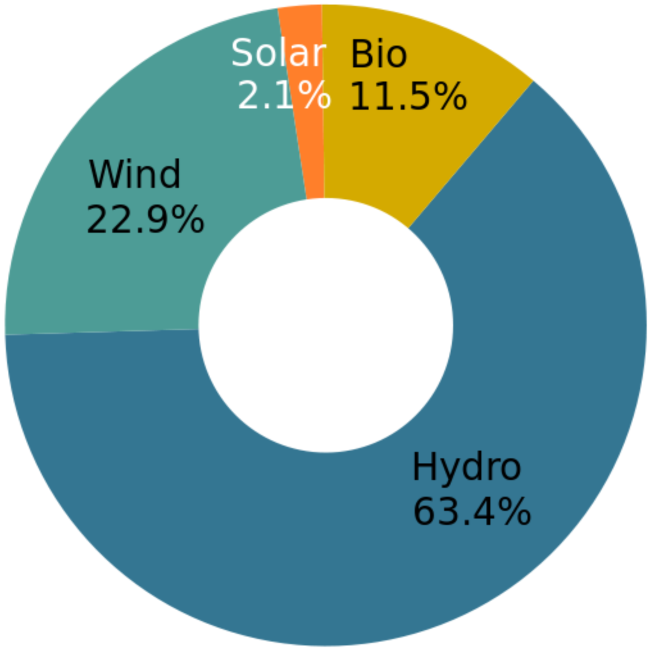

Figure 2: Percentage of electricity generation from renewables by energy source (Wikipedia, 2010).

It is estimated that Australia produced 29,678 gigawatt-hours (GWh) of renewable energy electricity (or equivalent) over the year ending December 2012, representing 13.14% of the total production in Australia. For comparison, in 2011, 29,302 (GWh) of renewable sourced electricity was produced (to year ending September 2011), representing 9.6% of the total electricity production in Australia. In 2006, approximately 9,500 GWh of electricity came from renewable sources, representing less than 4% of nationally generated electricity.

The Australian Government, at present, has not clearly outlined a level of support for renewable energy adoption apart from accepting that something needs to be done. Aside from this, opportunities to develop commercially viable operations in Australia to utilise spent litter from chicken meat production to produce electricity and heat are a real possibility if scale is planned correctly.

Anaerobic Digestion (AD)

AD is the biological degradation of biodegradable organic material within a controlled anaerobic (without air/oxygen) environment. Two products are produced from AD:

1. biogas

2. digestate

Biogas

Biogas is a renewable methane rich gas similar to natural gas. Biogas can be thought of as converted solar energy. Plants use sunlight to convert carbon dioxide and water into organic material (biomass). Naturally occurring anaerobic bacteria convert this biomass into biogas and digestate within an anaerobic digester. Biogas is the most flexible form of all the renewable energies. It can be used in its as-produced state or it can be upgraded to bio methane. Importantly, whatever can be done with natural gas and coal seam methane (CSM) can also be done with biogas/bio methane.

Methane

Methane (CH_4) is the combustible element of biogas. This is the same combustible element as natural gas and coal-seam methane (CSM).

Bio-methane

Bio-methane is upgraded biogas. In essence it is biogas with the carbon dioxide removed. Bio methane is completely compatible and fully interchangeable with natural gas and CSM. The most common use of bio methane is to inject it into the gas-grid as a renewable energy source.

Digestate

Digestate is the residual material left over after anaerobic digestion. Digestate will comprise both solid and liquid forms:

1. undigested carbon (predominately chicken litter/any unused lignin crop)

2. the bulk of the nutrients that were in the feedstocks

3. beneficial microbiological resources

Digestate can also be used as a feedstock for value adding processes.

Anaerobic digestion is a low emissions practice - producing only 11 grams of carbon dioxide equivalent per KWh, which is about two percent of the emissions for natural gas (443 grams per kWh) and one per cent of the emissions for unscrubbed coal (over a kilogram/kWh) (Clean Energy Finance Corp, 2015).

The biological processes

The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers, such as carbohydrates, and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide.

Digester Technologies

Many different anaerobic digester systems are commercially available. The following is an overview based on organic waste stream type (manure, municipal wastewater treatment, industrial wastewater treatment and municipal solid waste).

Anaerobic digestion systems for livestock manure operate to reduce methane emissions, odours, pathogens and weed seeds and produce biogas. They fall into four general categories:

Covered anaerobic lagoon digester. This is sealed with a flexible cover, with methane recovered and piped to the combustion device. Some systems use a single cell for combined digestion and storage.

Plug flow digester. This consists of a long, narrow concrete tank with a rigid or flexible cover. The tank is built partially or fully below ground to limit the demand for supplemental heat. Plug flow digesters are used at dairy operations that collect manure by scraping.

Complete mix digester. This consists of an enclosed, heated tank with a mechanical, hydraulic, or gas mixing system. Complete mix digesters work best when there is some dilution of the excreted manure with water (milking wastewater for example).

Dry digestion is carried out in upright, silo-style digesters made of concrete and steel with rigid covers. Dry digesters operate at 20 to 42 percent total solids, which allow them to combine high dry matter manure and crop residuals with very dilute liquid manures or co-substrates (Environmental Protection Agency, 2015).

The United Kingdom

In the UK there has been a substantial push by supermarkets for higher welfare poultry. The standards now required by the supermarkets include better welfare systems which include drier floors (Watson, 2014).

A great example of renewable energy utilisation which not only is producing all the farm's heat and energy but also providing drier floors for welfare, is via anaerobic digestion in the west of England, at Richard and Rob Gough's "Wigley Farm", Ludlow, Schropshire.

Figure 3: Wigley Farm, Ludlow, Schropshire. AD tanks on left, chicken sheds on right (2014).

Rob had four broiler sheds (115m long x 21 wide) each housing 50,000 birds which used miscanthus as the bedding material. No underfloor heating was used.

The key components of the system were:

500 kW CHP (combined heat and power generator)

Semi-plug flow primary digester (mesophilic) – 3200 m3

Digester storage tank - 3200 m^3

Buffer tank - 240 m^3

Solids separator

Rob's plan was to build another two farms in close proximity. The AD plant he had constructed in 2013 which was a 500 kW CHP was of sufficient size to power and heat all the sheds currently, with room for future expansion to 1.3 MW. This system was designed by Russell Marches from Marches Biogas.

Under this system, floors always remain dry and no topping up of miscanthus (a form of grass bedding) was required, ultimately achieving a higher welfare standard. The water temperature leaving the plant and heading to the chicken sheds for heating was 85°C. Consequently no odour was produced from the farm as a result of wet litter. Rob believed the cost of farming falls with AD by utilising the electricity, the heat, and the liquid digestate as a fertiliser and in the future, the solid digestate for chick bedding, which will all offer significant revenue streams.

This system used gas agitation for mixing the digestate (digestate temperature was 38.7°C). The liquid digestate produced was then squeezed and had the solids removed for field spreading then passing to the liquid digestate tank (3ML in size) which filled at 1% per day. The liquid digestate had a Nitrogen Phosphorus Potassium (NPK) ratio of 5:5:5. This product has a value off farm of £0.09 per litre ($0.17c AUD).

Rob explained the efficiencies of the system compared to Germany where 1.3 kW of energy is produced for every kilo of dry matter fed into the digester versus 1.40 -1.55 kW per kg dry matter fed in his digester. Rob believed that this was primarily due to the ability of the system to keep itself at full capacity. This was done via a laser beam mounted on top of the digestate tank indicating the level of digestate. As the level of the tank dropped the system topped up and adjusted automatically. Biogas was produced 99.21% of the time versus an industry average standard in Germany of 88% of the time.

The AD system established on "Wigley Farm" was under a repairs and maintenance contract which was linked to runtime hours. The construction company offered a guaranteed output runtime hours per year.

"Wigley Farm" now has expansion as a real possibility. Rob explained that by staggering the placement dates of chickens on new separate farms as one farm finishes with the heat requirement the next farm will take it up, evening out any peaks and troughs in thermal heat and energy output.

Canada

Time was spent with Jenny Pronto from Cornell University, Ithica PA. She was able to demonstrate what industries were utilising renewable energy in its simplest form, utilising their waste and how they manage the by-products.

We toured dairy farms in the Cornell area that had constructed anaerobic digestion systems on farm. Their primary concern was more about the odour issues surrounding their effluent ponds and the impact it was having on their surrounding neighbours, versus trying to reduce their electricity costs. This was a result of the Canadian Environmental Protection Agency (EPA) enforcing stricter controls on effluent management systems.

Electricity costs in Canada range between $0.08-$0.09 AUD per kilowatt hour versus $0.28AUD per kilowatt hour for Australian energy (Pronto, 2014). Therefore reducing energy cost was not the main driver for farmers in Canada (Pronto, 2014).

John Patterson an Ithaca dairy farmer, milked 1100 cows and used an RCM complete mix digester with a below ground tank which used external stirring paddles. He was paid $0.04 AUD per gallon to take milk whey from the local dairy processor to add to his digester ration. John has 2 x 250 KW generators creating his own energy along with putting energy back into the grid.

Greg Rejman also milked cows in the Ithaca area. He used a modified plug flow anaerobic digester from RCM. He milked 3200 cows plus 3200 heifers and calves.

One of the main reasons for visiting these Canadian dairy farmers was that they were reusing their solid digestate. This digestate is separated from the liquid, stored and dried. Greg used a rubber conveyor belt to form automatically created windrows for further drying and pasteurising. No additional labour was required. Once dried, they are returned to the stalls to be used as bedding underneath the dairy cows. This system is then continually replicated.

.*Figure 4: Bauer manure solids separator, Ithica, PA (2014).*

In contrast to an Australian broiler farm, these separated solids could be potentially used as new bedding material in either the brooding area or further down the shed as the flock is expanded, removing the need for purchasing new bedding material every batch.

After digestion, the liquid digestate which has been separated sits in ponds, fenced off and covered, waiting to be taken for spreading on paddocks. This farm utilised two 500 kW gensets producing 1 MW of electricity. In New York State 50% of the digester mix has to be from manure.

The Netherlands

Nuffield scholar Annechien Tene Have hosted my first days in the Netherlands. Annechien farms pigs at Beerta in the north where a 500 kW anaerobic digestion plant was recently constructed. The recipe currently used, but can change according to availability of ingredients, consists of:

- glycerine (10% dry stock 30% methanol)
- maize silage (produces 180 to 200 m^3 of biogas per tonne at 32% moisture)
- onions (produces 80 m^3 of biogas per tonne)
- potatoes (produces 150 m^3 of biogas per tonne)
- manure/straw (produces 25 m^3 of biogas per tonne).

Annechein's son Detmar explained that German AD plants using maize silage were producing 180 m^3 of biogas per tonne, yielding 45 tonne per hectare of maize or 2,520 m^3 of biogas per hectare.

The overall cost to run the AD plant was €0.15 EUR per kilowatt hour or $0.22 AUD per kilowatt hour. (Tene Have, 2014) The significance of the cost to run an AD plant is highlighted here when the cost of electricity in Australia currently is sitting around $0.28 AUD per kilowatt hour.

Sulphur build-up in the generator casing was an ongoing problem and needed to be removed. Sulphur scrubbers and nitrogen removers are also an additional piece of equipment which can also add to total revenue if sold off farm.

At another nearby biogas plant over the border in Germany, Yarp Bose the manager of the plant confirmed his recipe. It consisted of oats dust received direct from a mill, maize, cocoa beans husk and chicken manure. Yarp is paid €10 per tonne by the chicken farmer to take the farm's manure. This is the case right across the Netherlands, due to it being declared a nitrogen volatile zone. This plant was typical, producing 1,000 m^3 per hour of biogas, or 2.3 MW per day, enough to power 3'500 homes. Due to the high cost of feed inputs the plant had been reduced to 400 m^3 per hour of biogas production.

A small profit was generated from the plant and the take-home message was that we must have a direct contract with our ingredients supplier. This was absolutely critical for profitability, as a small number of brokers controlled all the inputs, in particular glycerine.

Nane Sterenborg's family, chicken farmers from south of Beerta, had been farming for 367 years. Nane was the 11th generation, his son will be the 12th. He had built a 500 kW AD plant utilising 2 x 250 kW generators. The profit driver in this instance was the cost of maize as an input and how, unless it is controlled via a contract, could render a renewable energy option useless. He explained that maize silage in 2007 was worth €28 per tonne and now in 2014 was worth €60 per tonne. The maize silage he had produced on farm was better sold to dairy local farms, rather than putting into his digester. His neighbour relied on outside inputs and had turned his digester off.

Germany

One of the most progressive AD plants seen in Germany was Enser Biogas – Emsland. The owners, a cooperative of farmers had built the plant around an existing wind turbine.

It produced 3.6 MW of power and supported four generators; one on-site and three off-site scattered around the industrial estate which was positioned alongside. The heat generated by the plant is used 100% by industry in winter and up to 60% in summer averaging 80% for the 12 months of the year. Sitting nearby was a wood-drying facility which had a generator on site driven by the biogas supplied from the A.D. plant. The heat coming off the generator was piped to shipping containers sitting close by full of firewood used for home heating. It had a high moisture content (45%) and needed to be dried.

The area had been planned for agriculture and industry to co-exist. Without proper planning from the local German authorities locating a large-scale anaerobic digestion plant within 500 m of industrial estate would not have been possible.

Lessons can be learnt from this situation and applied to Australian agriculture, particularly now as many industrial estates are located on the outskirts of towns and the distribution of biogas via underground pipes is common technology.

In Australia, designating an area as an “intensive agricultural precinct”, by councils would go a long way to promote development.

The recipe for this AD plant consisted of 90 tonnes per day of chicken manure, sugar beets and triticale silage, 35 tonnes per day of pig slurry and 15 tonnes per day maize silage. Fats and oils which were commonly used previously were not anymore due to the high cost. Interestingly, an allowance for parasitic load was put at 4%. This is the allowance that has to be made for the electrical motors on-site used in the operation of the plant.

Maize yields for the area were put at 55 tonnes per hectare average up to a top of 65 tonnes per hectare. In Germany up to 100% of an AD plants recipe could be derived from maize silage. More recently, the Danish government has implemented a directive capping maize silage addition to 25% of the recipe, emphasising the need to not rely solely on one energy crop. This will be reduced to 12.5% in 2018 (Sterenborg, 2014).

Adapting to Australian Conditions

With regards to anaerobic digestion any excess energy can be sold to the grid but is less likely in NSW given the feed-in-tariff of approximately 0.06 c/kWhr (Davidson, 2013). Excess digestate can be sold to other farmers as a mineral fertiliser substitute when not used for bedding.

The production and sale of energy and fertiliser provide additional income streams and contribute to a diversified farm economy, reducing risk. Digestate produced from the AD process is rich in nitrogen, phosphorous, potassium and micronutrients and has a higher utilisation efficiency rate than raw manure because nutrients are more available, the digestate is more homogenous and there is a better carbon to nitrogen C/N ratio. The digestate can be applied to the soil with the same equipment used for other fertiliser applications and crop nutrients can be more effectively targeted. The key to return on investment is that degradability of litter is around 70%. Levels below this start to reduce payback periods.

Another critical area for returns is that there needs to be potential for phosphorus recovery which can be sold into the agriculture market. This phosphorus recovered has potential to be half the value of the electricity produced and will make up one third of the revenue (McGahan et al., 2013).

Solar photovoltaic power generation

In Delaware, in terms of energy, farms commonly pay $0.08-$0.09 cents AUD per kilowatt (kW) hour, primarily used for ventilation. Renewable energy in the broiler industry is not common place, however, a farm owned by Larry Thomas in Delaware was reversing this trend. He had installed a 115 kW solar system to supply all of his broiler shed energy needs. The cost of US$425,000 was broken into 60% for the panels and 40% for the electric connection with net metering in place. It consisted of 12 rows of panels with four rows per control unit with panels measuring 60 cm x 127 cm. The panels were rated as having a 30 year lifespan and could withstand 200 km/h wind speeds. In wintertime, due to the cool weather, the electricity company allowed the farm to go into credit and then deduct from it during summer when consumption increased.

Ironically, whenever a blackout occurred, the whole system shut down due to the fact that it needs power to operate itself. No backup battery was available.

Adapting to Australian conditions

Although solar PV is highly regarded in many industries across Australia, its suitability to poultry farming is not as good as other forms of energy. One reason is that there is not suitable battery technology to store power. The other reason is that the demand for power, particularly in summer, continues 24 hours a day; therefore the operation is demanding power when the system cannot provide it. Many systems only supplement their power on farm. They do not solely rely on it.

Biomass (litter combustion)

Fluidised Bed Combustion (FBC) is a technology that has been used in power plants since the 1980’s. Fluidised beds suspend solid fuels on upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer (Joyce 2014).

This system from an Irish company, Bhsl, has now been installed on “Uphouse Farm” in Norfolk, UK. Ten years ago Nigel and Patrick Joyce, who have two eight shed farms, had to give away their manure. Power stations wanted to contract the manure and pay nothing. On top of this, Nitrogen Volatile Zones (areas of the country where nitrogen appears to be in excess in the water) are appearing and will play into the hands of litter combusting technology.

The combustion of litter on farm, for heating and ultimately electricity use, completely eliminates the need to rely on others to supply the ingredients for anaerobic digestion. One MW of power for an AD plant requires 12,000 tonnes of maize silage. “*It doesn’t detract from us being chicken growers - we are not plant operators*” (Joyce, 2014).

On farm, Nigel and Patrick have constructed a separate Energy Centre only 50 m from their nearest shed. The system is completely enclosed and operates on a negative pressure ventilation system which does not allow ammonia to escape from the building. A “Toploader” system automatically drags litter onto a conveyor belt to fuel the burner. No manual loading of burners takes place at all.

Heat incentives are paid by the government in the UK to any agricultural industry. For every kilowatt hour of heat produced they receive £0.059 ($0.12 AUD) per kilowatt hour plus another £2.1p ($0.04 AUD) per kilowatt hour if that heat is used on farm, a total of £0.08p per kilowatt hour. ($0.16 AUD) (Morton, 2014).

These heat incentives (or in our case heating and cooling) could be the basis for this kind of technology adoption in the Australian poultry industry.

Figure 5: Patrick & Nigel Joyce in front of Bhsl combustion plant, Norfolk, UK (2014).

Currently the system is burning 2,500 tonnes of litter per year, producing all of the farm's heating requirements. The fully enclosed and automated system aims to improve bio-security and reduce handling, field storage and spreading costs. The ash, which represents 8% by volume after combustion, is a concentrated nutrient-rich ash giving flexibility for use on crops.

Poultry litter now qualifies as “Biomass Fuel” under new EU Regulation. It is the latest Biomass Fuel legislation, following a unanimous agreement by the EU. This means that poultry manure, as an animal by-product, can be combusted as fuel on farms according to EU Regulation (Commission Regulation EU, 2014).

Patrick believes the performance improvements cannot be quantified. He believes his air environment is drier, the floors are drier and the birds are happier. He stressed that for every 1 litre of LPG burnt inside the shed in a normal brooding environment, approximately 800 mls of water is deposited in the air which needs to be extracted at some point.

“Uphouse Farm” would like to generate electricity as well. A company called Helix Power converts wet steam into electricity. The core technology is a novel rotary screw expander which recovers low grade energy from steam and uses it to generate electricity. This system is now being trialled with the fluidised bed combustion (FBC) to see if a fully encompassed renewable system can be implemented on farm.

Adapting to Australian Conditions

If a system such as combustion were to truly fit into Australian conditions it would need the heat converted into cooling for the warmer periods of the year. This can be done via an absorption chiller.

An absorption chiller is a refrigerator that uses a heat source (e.g. Cogeneration System, Solar, Natural Gas, Biogas) to provide the energy needed to drive the cooling system. These chillers are a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, or where noise from the compressor is problematic. In comparison to conventional air conditioning methods, these chillers consume far less electricity and therefore lead to considerable savings in primary energy consumption. (McGill, 2014).

Perdue Farms

Perdue Agriculture, a subsidiary of Perdue Farms has investigated a number of ways of dealing with the chicken manure produced in the Delmarva Peninsula. These processes included gasification, anaerobic digestion, pyrolysis and catalytic (diesel, petrol, biofuel) and combustion. Combustion was ultimately decided upon due to the fact that they still had nutrients left over from anaerobic digestion process which had to be dealt with. They had also examined a chicken litter baling plant that would enable them to ship chicken manure efficiently. The bales were 1500 kg and wrapped in plastic.

In 2006, they constructed a large chicken manure pelletising factory (Agri-recycle) located close to farms with a view to exporting all the product to the west of the United States USA. At the time of my visit and due to significant operational costs, they were planning on decommissioning this plant.

The new 14 MW combustion plant, which can burn 100,000 thousand tonnes of litter, is capable of producing thermal (heat) energy along with electricity to run both the feed mill (to supply all their broiler and brooder farms) and processing plant. Due to significant government insistence and the concerns with nitrogen run-off into the Chesapeake Bay, the company was forging ahead with these plans.

The Clean Energy Finance Corporation (CEFC)

The CEFC has already worked with a number of agricultural businesses to facilitate the development of renewable energy projects. It operates like a traditional financier for energy projects and works collaboratively with co-financiers and project proponents to seek ways to secure financing solutions. It can provide and develop financing solutions across the clean energy sector and seek to catalyse and leverage funding for commercialisation and deployment of clean energy technologies.

Government incentives

The renewable energy target (RET) has been developed by the Australian Government to encourage power generation from renewable energy sources. The government's target is to increase the contribution of renewable energy produced in Australia to at least 20% by 2020 with an additional 45,000 GWh generated from renewable sources such as solar, wind,hydro and biomass.

Chapter 3: Broiler management

Broiler Management - paradigm shifts

Throughout my journey in the USA a number of farms were utilising alternate management strategies that seemed appropriate for a range of conditions. These included:

Using multi-batch litter

Multi-batch litter was commonly used on the Delmarva Peninsula across all processing companies, due to the fact that they saw no detrimental effect on production primarily and no carryover disease issues to the next flock of day old chickens. The age of the multi-batch litter ranged from two years up to 10 years with the only management practice applied to this litter being de-caking where the crust is taken off the top (Brown, 2014).

Composting of daily mortalities on farm

Practically every farm visited was composting on-site using timber fabricated bays, eventually spreading the compost on farm or selling to other forms of agriculture

No tissue paper or feed was used during brooding – only trays

Commonly paper is placed on the top of reused litter or fresh shavings under Australian conditions along with starter feed to entice day old chickens to eat the feed.

Low pH water used for drinking

Due to the relatively high alkalinity farms were reducing their pH for optimum production.

Canadian poultry meat industry- supply management

Dan and Howard Cornwall (Dan is a Nuffield scholar) farm together and rear broilers and turkeys on the same farm. The Canadian broiler industry does not compare broiler growers to each other. Interestingly, the growers do not receive a pool or league table which compares the top grower to the bottom from a range of key performance indicators, the primary indicator being FCR or feed conversion ratio. There was no competition amongst growers, just the knowledge that they were paid two to three days after birds were processed, based on the kilos of meat produced. This is in stark contrast to the Australian business model where growers are ranked, fees reduced for any inefficiencies and payment terms are in control of the processor.

The Canadian chicken industry operates under a system known as “supply management”. This system matches production to Canadian demand. Consumers get good value for their money and a reliable supply of quality food at reasonable prices. Farmers receive their returns from the marketplace without relying on subsidies or taxpayer dollars. The Canadian market is open to a predictable level of imported food.

Supply management is recognised by federal and provincial governments as an effective risk management program. With its three pillars (import controls, production planning and producer pricing) the supply management system for chicken continues to evolve to meet the changing demands of the marketplace.

Pillar 1: Import controls

Matching supply with demand for food allows Canadians to count on stable food prices. This, along with the predictability of imports, ensures that it is possible to make a living in agriculture. To achieve this they need effective tariff rate quotas with over-quota tariffs that control imports of dairy, poultry and egg likes in all their forms

Pillar 2: Production planning

Under supply management, farmers plan their production to provide a steady supply of quality food that efficiently reflects changes in consumer demand. This prevents sudden price shifts as products move from farm to plate.

Pillar 3: Producer pricing

In Canada, farmers collectively negotiate minimum farm gate prices for milk, poultry and eggs. By acting together, farmers negotiate a fair price for their products based on what it costs to produce them. Farmers do not set wholesale or retail prices.

This system has the support of Canadians. 86% of Canadians feel that it is important that the chicken they buy is from Canada. 92% of Canadians agree that it is important that the government actively defend the interests of the Canadian chicken farmers (Chicken Farmers of Canada, 2010).

In comparison to Australia, if a new farmer in Canada was to build a new eight shed 450,000 bird broiler farm, considered standard by many, they would need to buy “quota only” which would cost AU$34 million. Understandably out of the reach of many new young farmers.

The USA: Delmarva Peninsular

The tiny Delmarva Peninsula on the East Coast of the USA, produces about as much chicken as all of Australia put together. It is the most heavily concentrated area of chicken sheds in the USA with more than 1,500 farms. The area generates US$2.8 billion annually with approximately 13,500 people working in the industry.

Kenny Bounds, a great Nuffield supporter from Mid Atlantic Credit, along with Bill Brown from Delaware University hosted my Delmarva visit.

Due to the size of the USA industry, farms are segregated into small bird farms and large bird farms. In Australia it is common practice to have one shed housing four market specifications. In Australia , at approximately day 34, 15% of the shed is taken for processing then another 15%, at day 42 and another 20% at day 49. This leaves 50% of the shed which is targeted at the breast bone out market. In total, four thin-outs occur targeting each specific market. In the USA, one large bird farm will be allocated enough chickens to just have one full cleanout at 56 days of age for the breast bone out market. Growers choose which market they would prefer to grow for, allowing them to concentrate on other parts of their farming enterprise.

Chapter 4.: Animal welfare lobby

“Better Living”

“Better Living” is a Dutch welfare standard which has emerged as a result of activists campaigning for better welfare standards for both egg and meat chickens. It comprises a star system:

One Star is the outside raring of poultry.

Two Star is a slow grown meat chicken with a bird stocking density of 32 kg/m^2.

Three Star is 100% organic.

The Albert Heijn supermarket chain has committed (in 2015) to supplying all chicken to consumers based on the “Better Living” standard. Also included is a requirement to source certified sustainable soybean free of Genetically Modified Organisms (GMO) and for day old chicks to be placed on straw bedding. Customers of the supermarket chain were notified that prices would increase by 25% of the breast meat price and that 4-5% would be passed on to the grower (Dirk, 2014).

X-Treck: A welfare innovation

Animal welfare concerns have also passed through to broiler equipment companies and how they deliver different products to the market. An innovative system being trialled at the moment in the Netherlands is called the X-Treck. It combines the hatching and brooding phase on farm, normally done in a hatchery. On farm hatching fulfils three basic needs of a chick from the start: food, water and fresh air.

Setter trays with 18 day–incubated eggs, are placed on a rail system that is suspended over the length of the broiler shed. The rail system is positioned so that airflow can surround the eggs during hatching.

Due to a natural variation in development, the hatching time of a chicken is usually 24 to 40 hours. The first chicks generally hatch after 19 days of incubation with the last chicks hatching at day 21. This results in the oldest chicks being about two days old at the moment of chick collection from the hatcher.

It is claimed that:

- immediate post-hatch feed and water access provides energy for organ growth and the development of key physiological systems such as the immune system and thermoregulation.
- having direct water and feed access in the shed boosts the intestinal development and stimulates digestive capacity in the growth period.
- on-farm hatching strongly reduces the risk for cross contamination
- a higher health status results in uncomplicated management of the birds (Blox, 2014).

Reducing ammonia, dust and odour

Intensive farming in the Netherlands and Germany are coming under greater scrutiny due to the dust and odour emitted from sheds. It is now mandatory when building a new poultry or pig shed that an air washer be installed to reduce ammonia, dust and odour (Kluskens, 2014).

New buildings are designed in such a way that all air being extracted from the shed passes through a cool pad system constructed across the ends of the fans. In the case of a biological air scrubber, water passes down through these cool pads which are generally 200 mm thick. Contaminated water then passes through a filtration system whilst being recirculated. Chemical air scrubbers use sulphuric acid to strip ammonia out of the air producing nitrogen sulphate. In pigs, these systems are achieving 95% ammonia reduction and 30 to 40% odour reduction (Kluskens, 2014). However, the systems are expensive with farmers requiring government support.

Recommendations

1. That industry, relevant stakeholders and government work together to come up with a relevant **<u>model for renewable energy adoption</u>.** Adoption of the UK tariffs would be a good start.

2. That processors and chicken farmers work together alongside relevant government departments to develop a "**<u>Filling the Abattoir</u>"** financial model where growers who wish to innovate to reduce costs in their operation can do so. This would benefit processors through improved livestock and financial performance and better farm and abattoir utilisation.

3. In the short term, a **<u>multi-batch litter reuse program</u>** be established nationwide across all processing companies reducing the need for shavings and straw which reduces nitrogen volatility on waterways, fending off a potential problem.

4. That **<u>"Intensive agricultural precincts"</u>** be established nationwide to allow for both intensive agricultural production and renewable energy production to co-exist. Synergistic farming systems could be situated together so that heat and cooling generated from the anaerobic digestion or combustion systems can be utilised, such as meat chickens and glasshouse hydroponics or in dairy, meat chickens and glasshouse vegetable production.

5. That the demands by the animal welfare fraternity for greater welfare standards be looked at as an opportunity not a threat; an opportunity for better standards but also an opportunity to combine with renewable energy systems that provide for a more optimum chicken growing environment.

References

ACMF (2015). Australian Chicken Meat Federation. www.acmf.com.au

Chicken farmers of Canada (2010). “Good business - great chicken” www.ontariochicken.ca

Commission Regulation European Union (2014). Use of animal by-products and derived products as a fuel in combustion plants. Article No. 592 2014. June, 2014

Blox, T. Venlo, Netherlands. (July, 2014.) G Hebblewhite, Interviewer.

Brunton, C. (2009). Chicken Meat Usage and Attitude Survey. RIRDC. Pub. No. 09/080

Clean Energy Finance Corp (2015). www.cleanenergyfinancecorp.com.au

Davidson, C. (2013). Antigen P/L, Tamworth. G Hebblewhite, Interviewer.

Delmarva Poultry Industry, Inc (2013). “Look What the Chicken Industry Is Doing for Delmarva” Facts about Delmarva’s Meat Chicken Industryf\factsmd2010 www.dpichicken.org

Dirk, N., (2014, June). Rabobank Senior Research Analyst, Utrecht. G Hebblewhite, Interviewer.

Domgas Alliance (2012). Australia’s Domestic Gas Security. Report 2012

Environmental Protection Agency, (2015). http://www.epa.gov

Gough, R. (2014). Manager “Wigley Farm”, Ludlow, Schropshire. UK

IAASTD (2008). International Assessment of Agricultural Knowledge, Science and Technology for Development. Intergovernmental Plenary in Johannesburg, South Africa 7-11 April 2008.

Joyce, P. (2014, July). Uphouse Farm, England. G Hebblewhite, Interviewer.

Kluskens, R. (2014, July). Venlo, Netherlands. G Hebblewhite, Interviewer.

McGahan E., Barker S., Poad G., Wiedemann S., Batstone D., (2013). Conversion of Waste to Energy in the Chicken Meat Industry. RIRDC Publication No. 12/097

McGill D. (2014, June). Helix Power. ADBA Biogas Conference, Birmingham. G Hebblewhite, Interviewer.

Morton, C. (2014.) AD & Biogas News. Issue 22 June 2014.

Pronto, J. (2014, March). Dairy Extension, Cornell University, Ithica PA. G Hebblewhite, Interviewer.

Sterenborg, N. (2014, June.) Netherlands. G Hebblewhite, Interviewer.

Tene Have, D. (2014, June). Netherlands G Hebblewhite, Interviewer.

Watson, K. (2014, July). Sainsbury Agriculture Manager Poultry. G Hebblewhite, Interviewer.

Wikipedia (2010). Percentage of electricity generation from renewables by energy source. (wikipedia.org/wiki/Renewable_energy_in_Australia)

Plain English Compendium Summary

Project Title:	**Broiler management and cost reduction using renewables**
Nuffield Australia Project No.:	1315
Scholar:	Guy Hebblewhite
Organisation:	Countryside Farming Trust “Moana”, Somerton Tamworth NSW 2340 Australia
Phone:	0432 121 450
Email:	guy@puremanure.com.au
Objectives	Australian chicken meat farmers are wanting to reduce costs associated with their operations and at the same time improve overall efficiency. Utilising litter in an energy production system via combustion or anaerobic digestion was examined as a way of generating renewable energy to help reduce these costs. The objective of this report was to summarise visits to different parts of the world where these technologies were in use, with a view to identifying the opportunities of implementing such technologiesto improve meat chicken management overall.
Background	Chicken meat is an affordable and low fat source of protein enjoyed by families across the country. It is more popular than beef and has become increasingly popular in recent times. The by-product of this popular white meat, poultry litter, has been traditionally land spread due to its relatively low cost to primary producers. More stringent legislation controlling land spreading of litter and the increased costs of energy (electricity and LPG) have caused chicken farmers to look at extracting additional value from their litter in the form of energy.
Research	The research was conducted over an 18 month period starting in April 2013. It was conducted in Canada, America, the Netherlands, Germany and the UK
Outcomes	Renewable energy in the form of anaerobic digestion or biomass (litter combustion) has the potential to be applied to the Australian chicken meat industry.
Implications	Today’s broiler farmers face increasing energy costs eroding profitability. Biomass combustion is a commonly used renewable energy technology of converting biomass (litter) to heat. Heat energy is used to turn water into steam which can be used in the creation of electricity or as a transportable form of heat. Anaerobic digestion microorganisms break down organic material (litter/corn silage) in the absence of oxygen. One of the end products is biogas. Biogas can be combusted to generate electricity and heat or can be processed into renewable natural gas and transportation fuels. Renewable Energy will be a powerful tool to assist broiler farmers lower energy costs in the future whilst maintaining environmental sustainability through possessing the lowest carbon footprint of any protein produced.
Publications	