Feedlot Energy System and the Value of Manure

Gasification of feedlot manure for energy in feed manufacture

A report for

By Don Madden
2010 Nuffield Scholar

December 2011

Nuffield Australia Project No 1015

Sponsored by: Rabobank

Scholar Contact Details
Don Madden
Smithfield Feedlot
Okeden Road Proston QLD 4613

Phone: 07 41689146
Fax: 07 41689478
Email: don@feedlot.com.au

Nuffield Australia Contact Details

Nuffield Australia
Telephone: (03) 54800755
Facsimile: (03) 54800233

Mobile: 0412696076
Email: enquiries@nuffield.com.au
PO Box 586 Moama NSW 2731

Table of Contents

Foreword

Renewable energy has become the new buzzword during the latter part of the last decade with the combination of spikes in commodity prices, perceived energy shortages and community concern of rising emissions. Real or perceived, these issues have and will continue to spur government policy, industrial innovation and business strategies to consider what can be done to sustain our energy based economies.

A feedlot lends itself to an efficient renewable energy cycle where its waste (manure), contains an energy value that can be used as an energy input in its feed manufacturing process (steam flaking of grain). Pricing carbon will have implications for the feedlot industry with manure management identified under the Carbon Farming Initiative being tabled to Australian parliament.

My investigation sets out to explain what technologies are available, if any are being adopted and the viability of their commercial application in a feedlot situation.

This project was funded by Rabobank and Nuffield Australia.

Acknowledgements

I am eternally grateful to Nuffield Australia and Rabobank for facilitating my journey and experiences gained over the last two years. Also the opportunity to meet and share travels with some great people who are part of the Nuffield family.

My thanks to the many hosts, who gave up their time and knowledge to assist and guide me. Not only in my area of interest but also in gaining a broader understanding of how the world works across a vast range of issues.

To my associates and staff whose support and dedication to deal with work challenges that could have cut short my journey, especially during the floods earlier this year.

Without doubt my wife Barb and children James, Annabelle and Ned, who not only managed to deal with my absence but who bravely joined me on parts of the journey that was well outside their comfort zones especially the food.

Abbreviations

SCU – Standard Cattle Unit

U.S – United States of America

CPI – Consumer Price Index

HP – Horse Power

Kwh – Kilowatt Hour

ADG – Average Daily Gain

FCE – Feed Conversion Efficiency

COG – Cost of Gain

USDA – United States Department of Agriculture

N – Nitrogen

P – Phosphorous

K – Potassium

T – Ton (Metric)

CH4 – Methane

CO2 – Carbon Dioxide

AD – Anaerobic Digestion

C – Degrees Celsius

Btu – British Thermal Unit

Lb – Pound

Mw – Megawatt

HHV – Higher Heating Value

Kg – Kilogram

Mj – Mega joule

GHG – Green House Gas

ISCAT – International Centre for Appropriate & Sustainable Technology

GPS – Global positioning Satellite

OSU – Oklahoma State University

Executive Summary

Intensive beef production systems such as the feedlot industry are based on a high turn-over low margin business models centred on the efficient conversion of energy inputs to energy outputs. This report is aimed at feedlot operators and associated agencies considering the worth of feedlot manure as energy producing fuel within a feedlot.

The objective of this report is to analyse the energy system within a feedlot, consider what options are available for utilising an energy output (manure), the value of that manure energy, and what implications emissions and their trade may have on its use.

Australia's industry sectors, as well as many other nations of the world have reacted to the surge in energy commodity prices during 2007. In combination with this price surge and government policy around carbon reduction the search for renewable energy sources has accelerated, resulting in an array of alternative solutions emerging and re-emerging around the world. The new policies have placed traditional commodities used for animal production into the general energy commodity market, thus putting a strain on feeding margins. This has the two fold effect of forcing cattle feeding operation to extract more energy out of increasingly more expensive grain and reducing the energy costs of the manufacturing processes necessary to achieve this.

Most large size commercial feedlots use steam flaking technology to achieve a higher energy utilisation of grain by livestock. This requires the energy intensive process of generating steam through the burning of oil, gas or coal. Gasification of biomass is one of the technologies that have re-emerged as a possible solution to address this situation, but as with most power generation systems the concept must address several simple fundamentals being: the cost of extraction including capital cost, conversion efficiency and distribution of power.
The intensive cattle feeding industry provides a unique combination of factors that warrant consideration for renewable energy generation as it has available a low cost, self-replenishing fuel stock being a by-product of its primary activity and an energy demand on the same site. This provides the opportunity for a closed loop energy system that may provide a substantial return on capital investment.

Existing bioenergy developments have proved difficult to justify in feedlots in the U.S and as a result there has been little interest in this area, anaerobic digesters are not suited to dry manure feedstock and conventional gasifiers struggle to cope with high ash content of feedlot manure.

To provide the energy needed for steam production feed manufacturing in modern feedlots, specialised equipment is being developed to efficiently gasify feedlot manure and overcome the fuel limitations in existing gasification systems.

The development and adoption of this technology will have positive implications for feedlot margins, environmental management and carbon reduction outcomes. However its relevance in the total feedlot energy system needs to be kept in perspective to warrant investment.

Introduction

My background in the meat industry began in the meat processing sector. Here an appreciation of process control, quality management, division of labour and technological advancement gave a solid basis for the advancement of productivity and a reduction in cost of production. These principles have been easily transferred to the feedlot industry over the past 12 years of my involvement with it.

Our feedlot situated on the eastern slopes in South East Queensland is an 18,500scu capacity operation finishing cattle for both the domestic trade and export markets. We are a family owned and operated enterprise that have always adopted innovative technologies in our quest for efficiency gains to benefit not only our profitability, but also to reliably supply our customers at a competitive cost of production for the 60,000 head that are turned over annually.

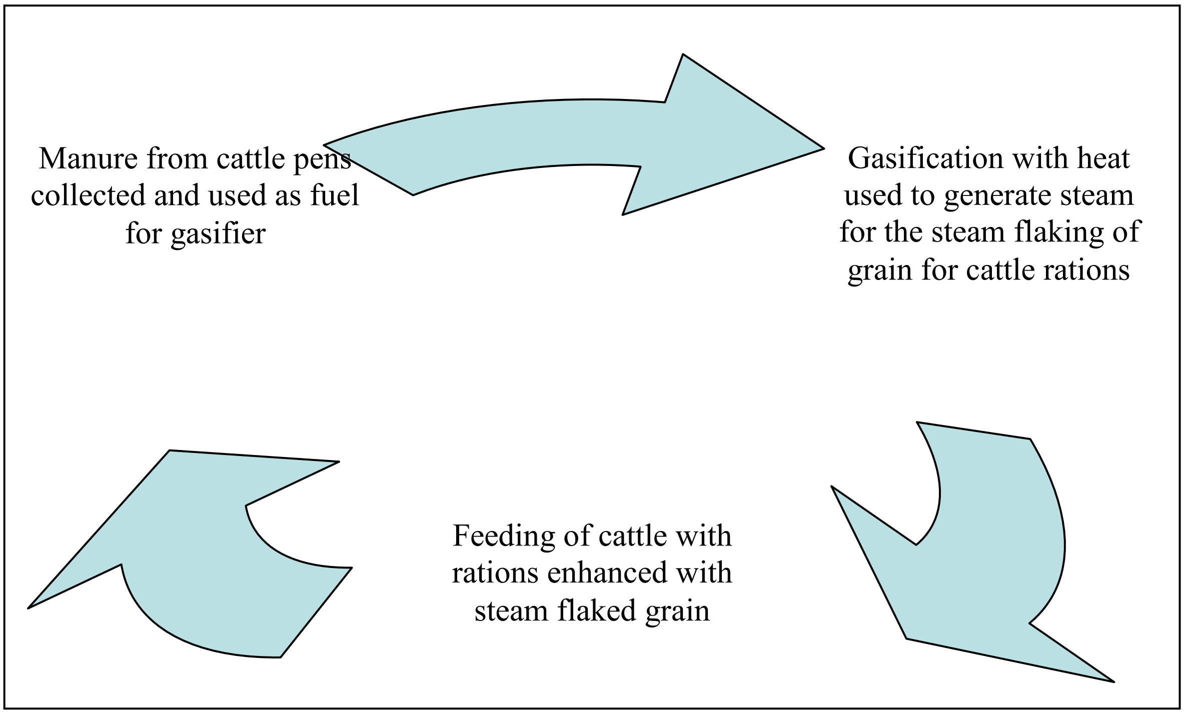
The feedlot industry in Australia has evolved from the need to provide consistency in the beef supply chain often disrupted by the seasonal effects of drought and flood with their influence on pasture and forage grazing systems. Large ruminants like cattle are an effective mechanism to extract nutrient from Australia's vast rangelands not normally suited to arable food production. Breeding and growing operations are very efficient and well suited to the large, low cost grazing systems particularly in the northern parts of the continent. However when a bovine reaches its mature frame score, it's nutritive requirements are significantly more demanding to achieve the necessary meat and fat levels demanded by the end point specifications at the point of processing. Drought and low fertility of pasturelands places constraints on the animal's ability to economically achieve these market end points on a year round basis necessary to satisfy the next stage of the supply chain – the processor.

Feedlots are facilities to provide the year round consistent finishing of cattle to achieve market end points. This is achieved through intensive feeding regimes providing high energy diets consisting of grain, dietary supplements, co-products and fibres aimed to achieve maximised feed conversion efficiency, average daily gain and a minimised cost of gain.

In Australia most commercial feedlots have evolved to a size ranging from 5,000 to 40,000 head capacity due to the efficiency gains that are achieved from scale. The high volume – low margin business model that has become the norm requires that maximisation of occupancy and the squeezing of efficiencies to maintain adequate margin. Feedlot managers are continually looking for ways to improve efficiencies. One key area of interest is energy systems and looking for opportunities to reduce, convert, capture or profit from any area that maybe available.

One of the opportunities available to feedlots is the utilisation of an energy output (manure) and transforming it to an energy input (steam) for the feed manufacturing process, all within a closed loop energy system.

Closed Loop Energy System



The Feedlot energy transfer system

A feedlot is best described as an energy transfer system, aiming to maximise the efficiency of energy transfer through the entire system.

Energy input	Energy conversion	Energy output
Feed	Cattle	Carcase
Fuel	Machinery	Manure
Electricity	Labour	

Energy inputs – Grain

Grain is by far the largest energy input in a feedlot, while grain like any tradable commodity is susceptible to price fluctuations due to the demand – supply cycle throughout the world, the past decade has seen a significant shift in markets that has coincided with the rise of the ethanol industry.

In the U.S this year the amount of corn used by the ethanol industry will surpass the usage by the livestock feed sector. This growth can primarily be contributed to the $0.45 per gallon blender's credit that the refineries receive from the U.S government at a current cost of $7.7 billion dollars per year.

The 2010/11 marketing year will see 126 million tonnes or 37.9% of U.S corn consumption used in the production of ethanol; this would further pressure U.S corn stocks and cause upward pressure on prices. (Australian Bureau of Agricultural Resource Economics, 2010)

Corn prices have roughly tripled since in 2006 the U.S government decision to mandate that ethanol be blended into gasoline. The CPI for meat and poultry has risen steadily with it. The ethanol industry in the U.S has continued to expand capacity beyond the point at which they can satisfy the 10% mandate of U.S gasoline, hence the recent passing of a bill to increase the mandate to 15%. (Condon, 2011)

The relationship between an increasing demand driven by subsidised blenders credits and mandates to total U.S corn production has simply driven an increased production trend as seen below in figure1. While the correlation of this to the price of corn can be seen in figure2.

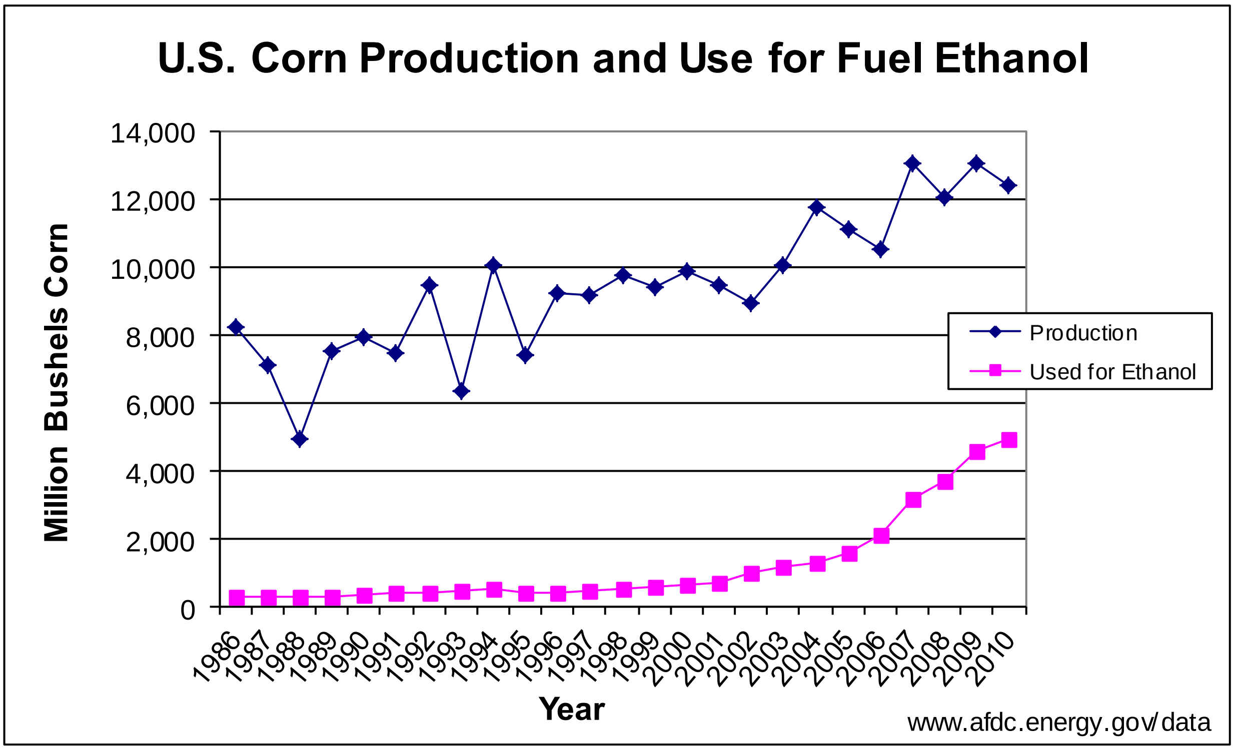


Figure 1: Corn production and ethanol use (AFDC)

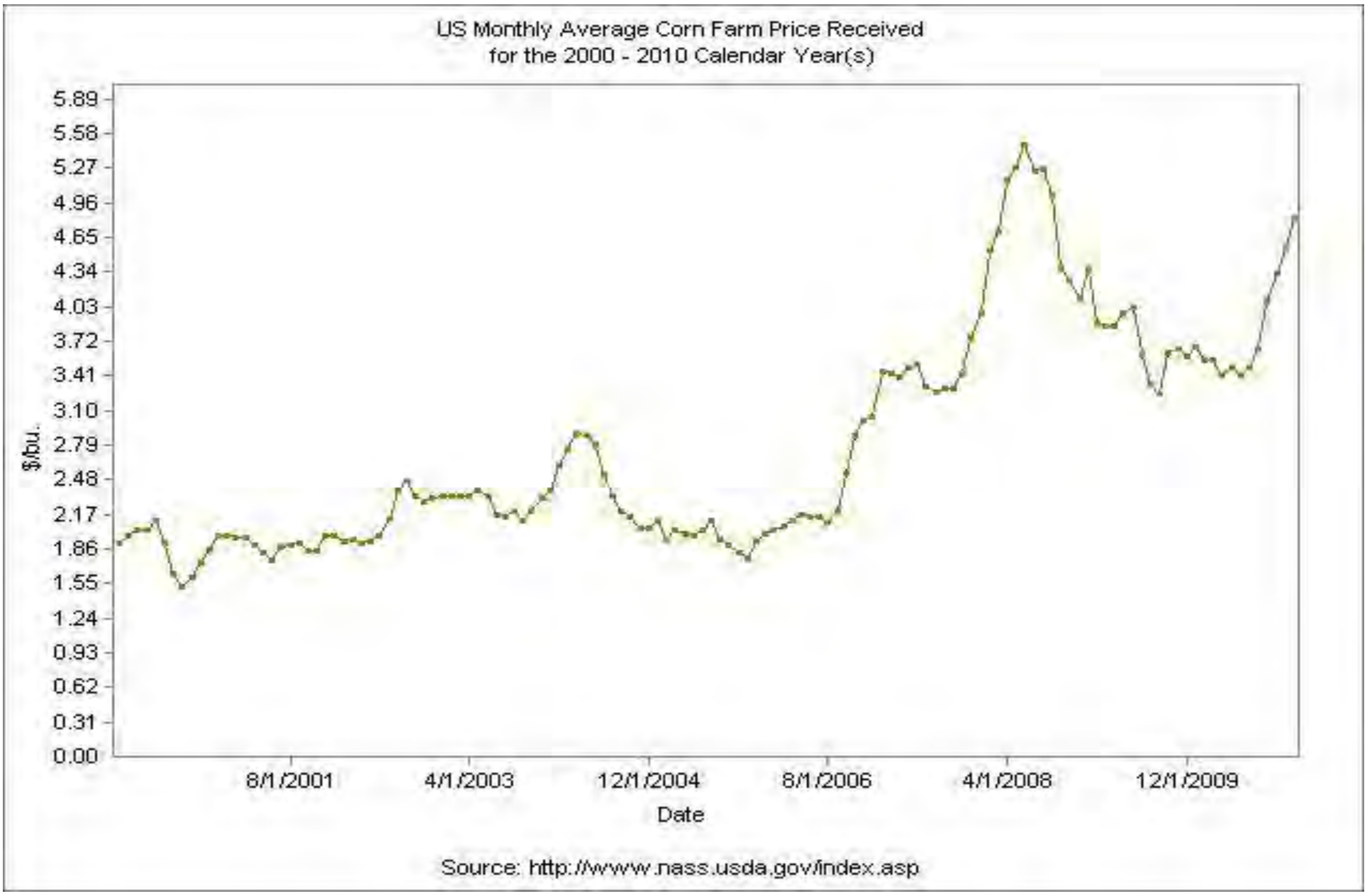


Figure 2. Corn Price (USDA)

Rising demand for ethanol directly translates into rising demand for corn, at least until alternative biofuels (such as cellulosic derived ethanol) can become more price competitive.

Demand for ethanol is directly related to the ratio between oil and corn price – how much ethanol can be sold for (the price of oil) divided by the cost to acquire corn. If this ratio is >90%, manufacturers will earn enough money to cover the cost of building an ethanol plant and to use it. However it is the subsidies (45c/gal blender's credit) that make it still profitable even when the ratio is below 90%.

Much research development has been invested into cellulosic biofuel production in the U.S, from seed stock such as switchgrass however cellulosic ethanol groups are not powerful enough to get grant generation and that the logistics of moving low energy feedstock any distance will provide challenges to its viability.

There are many new ethanol plants under development particularly in the corn growing areas to the north in states such as Iowa. The implications for the cattle feeding businesses have been seen in the shifting of feeding operations to take advantage of the availability of distiller's grains which is a by-product of the ethanol distilling process. With inclusion rates of 20-40% in cattle diets, this feed ingredient is now very vital in making up any shortfall in grain stocks caused by increasing demand. As the logistics to utilise this co-product demands proximity to the ethanol production facilities, many of the now viable feedlot operations are located in the corn growing areas such as Iowa.

As the Chicago corn-futures will continue to set the basis for much of the world trade for feed grains, the implications of the expanding U.S ethanol industry will be felt throughout the world and as grain has and will continue to be the largest energy input into a feedlot, its progress is of concern.

Energy inputs – Fuel

There are many uses for the fuel inputs in a feedlot, but the most critical is its role in maximising the energy conversion efficiency of the grain. The technology that has widely been adopted throughout feedlots to achieve this goal is steam flaking – a process combining moisture, heat and mechanical shearing action to alter the starch matrix of certain starches to provide an improved energy availability to the ruminant. Its greatest influence is on grains with strong starch/protein interactions such as sorghum, with relative energy levels increased 25%, barley 7%, wheat 6.6% and corn 4.5% (Huntington, 1997). Steam flaking also improves the physical characteristics of the grain to improve digestive function such as increased surface area, particle size (flake integrity) and some hygiene benefit. (Lawrence, 2008) *The costs of these energy inputs have trended upwards over the past decade as illustrated in this table.*

Table 1. The change in cost of feedlot energy inputs (diesel, gas, electricity, wheat) over last five and ten years.

Energy Inputs	*1998*	*Year 2003*	*Year 2008*	*Year 2011*
1. Diesel $/ltre	*0.72*	*0.97*	*1.50*	*1.38*
2. LPG $/ltre	*0.11*	*0.23*	*0.46*	*0.42*
3. Electricity c/kWh	*12.5*	*14.5*	*16.9*	*19.6*
4. Coal $/t	*53*	*69*	*105*	*150*
5. ASW Wheat $/t	*235*	*256*	*295*	*245*

Adapted from (Lawrence, 2008)

An example of an average 20,000 head capacity feedlot requiring the flaking of 150 tonne/day of grain using three 18inch diameter steam flaking mills would require a steam boiler capable of generating 200 to 250 HP of power. This would require fuel consumption in the vicinity of between 6 to 9 litres of diesel per ton of grain flaked and 9 to 14 kw of electricity per tonne to run the mills and associated handling equipment. Fuel and power usage varies depending on the type of grain being processed but a range of $6-$9 per tonne for fuel and $1.70 to $2 per tonne for electricity would fit most flaking operations in Australia over the last 3 years. These figures would equate to around $300,000 to $450,000 per annum for fuel and $85,000 to $10,000 for fuel and electricity respectively for an average 20,000 head feedlot. (Nutritional Services Associates, 2010)

Steam flaking is predominantly the most used method of grain processing in many feedlots with a capacity beyond 10,000 head throughout Australia and the U.S. Fire tube and water tube scotch marine boilers are the most common pieces of equipment used in steam generation, primarily fuelled with gas, coal or oil.

While diesel and gas (butane & propane) prices have tracked each other on a calorific value consistently over the past 5 years in Australia, coal as an energy source has been a significantly lower cost for its relative heating value. However capital and running costs are considerably higher for the generation of steam. Most of the feedlots throughout the mid-west rely on natural gas as this energy source is significantly less expensive than liquefied propane or diesel. Natural gas energy cost when converted to $ per tonne of corn flaked can range from $0.74 to $1.25 per tonne compared with $5.58 for propane, this gives the feedlots in the mid-west a considerable advantage.

Energy conversion

Conversion of the energy inputs to energy outputs centres mainly on animal performance directly measured by average daily gain (ADG), feed conversion efficiency (FCE), and cost of gain (COG). The priority given to these measures depends on the price of inputs and the price received for the outputs; for example across many feedlots emphasis has shifted from FCE to COG due to introduction of low price co-products such as distiller's grains from the ethanol industry and low margins for the carcase outputs. However many feedlots strive to maximise these parameters as a reflection of overall animal performance.

Many factors influence animal performance but they can be grouped in five main areas:

Animal factors:

- Breed and genetics
- Body weight, sex and age
- Compensatory gain
- Immune status
- Rumen microbial population.

Environmental factors

- Cold and heat stress
- Mud impacts
- Photoperiod (day length)

Management factors

- Implant strategies

- Pen Maintenance
- Health management
- Sorting management

Dietary factors

- Background nutrition
- Dietary energy
- Roughage concentration
- Mineral and vitamin balance
- Palatability

Economic factors

- Carcase end-point
- Specifications
- Forward contract obligations
- Sale price
- Feed and medical cost
- Interest costs
- Discount/Premium structure

The large gains in the efficiency in the beef industry over the last few decades can be seen in the following graph.

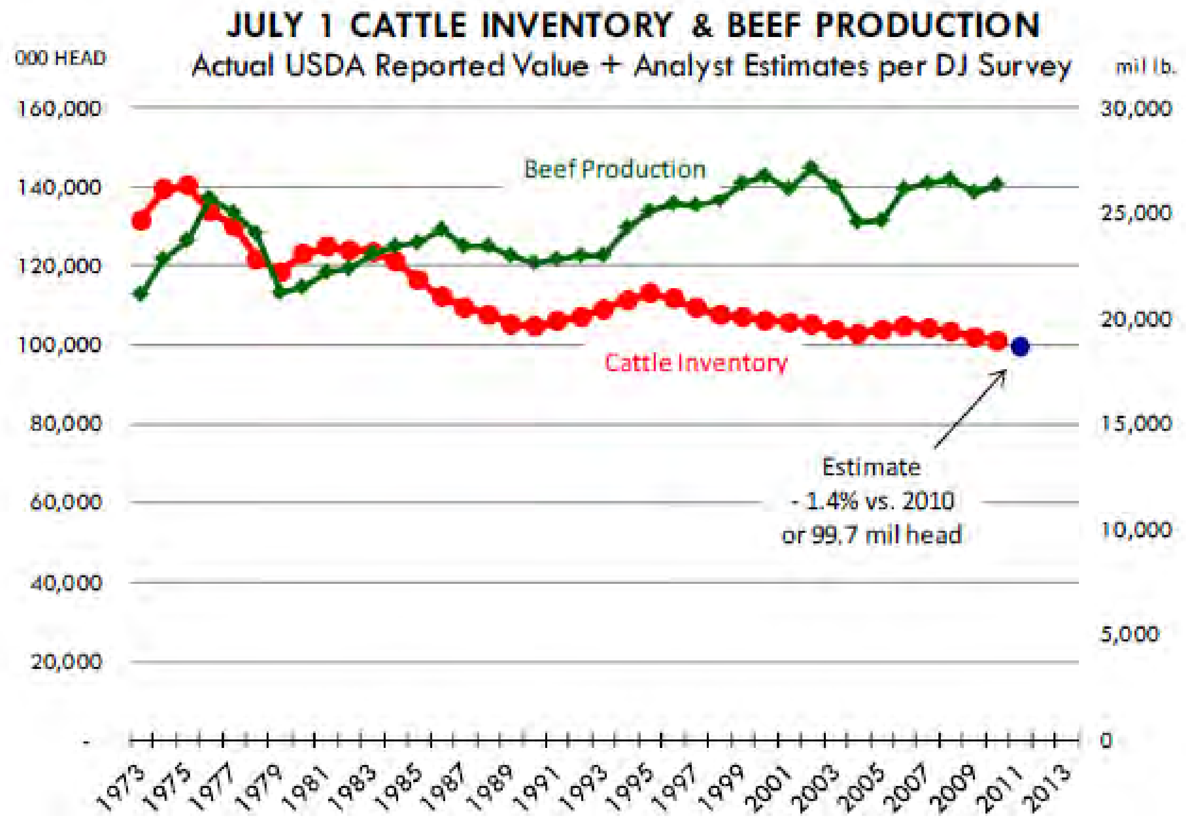


Figure 3. Inventory and Production U.S **(CME, Vol 9 No.138 July 2011)**

The rise of feedlot operations has allowed US beef producers to turn cattle faster and also significantly increase the amount of beef produced from steers and heifers being placed on feedlot rations. This is due in part to changes in feed utilisation which has almost halved over the last 40 years from feed/gain ratios of 9:1 to ratios below 5:1.

The major changes that have occurred over this time have been; feeding management, genetics, steroidal implants, ionophores and more recently beta agonists.

Energy Outputs

The major energy output is the carcase, the value of which is aimed at covering the initial animals cost and inputs. Any margin either positive or negative is subject to the demand-supply cycle that is operating at the time.

Many commercial feedlots factor their operating expenses into a margin on the cost of feed that goes into the animal. This allows forward contracts or futures to be arranged with little or no margin on the carcase, however for this to be commercial exacting carcase end points need to be achieved to prevent discounting at the processing end of the arrangement. The feedlots ability to achieve these end points along with maximising feed efficiency will ultimately result in the operations profitability.

The other energy output is manure, the traditional use for feedlot manure in Australia has always been broad acre spreading, determining its value can be difficult with many benefits being in the longer term to synthetic fertilisers.

In Australia feedlot manure is becoming an important fertilizer in the northern cropping areas but needs to be managed carefully to obtain satisfactory crop yields and achieve good value. With around 450,000 cattle on feed in Queensland, there is close to 500,000 tonnes of manure to be utilised as fertilizer each year. The value of N and P in feedlot manure is around $37/T for fresh manure and $43/T for aged and composted manure. When the value of K is considered, the manure has a value of $54/T fresh and $61/T aged. Sulphur and Zinc can add an extra $2/t in nutrient value. (Wylie, 2008 Feb 2nd)

Some composted products are available but generally, composting adds to the cost of manure without providing significant benefits. It is wasteful with major losses in nitrogen and organic carbon (around 50%) during the composting process. (Wylie, 2008 Feb 2nd)

One of the most limiting factors on the value of manure is freight between the feedlot and the area of application. This distance can discount the value down to zero or as in the case of many feedlots in a concentrated area such as Herford – Texas, manure removal is a cost to the feedlot.

Another factor that affects the value of manure is the method of removal from pens, with quality affected by the amount of contaminants – dirt, sand and wood that can be picked up during collection. Regular pen scraping (using box scrapers) verses removal by front-end loaders which can bring up dirt from the pen floor by in-experienced operators. Other manure management practices such as screening and partial decomposition can add value to the manure by reducing particle size, however these practices can add to the overall cost of the process thus having to be recovered through the sale price. Composting which can be used as an effective method of mortality disposal also incurs a large loss of nitrogen via volatilisation on top of the extra management cost to achieve a satisfactory process and product.

Mortality composting is the biological decomposition and stabilisation of the biodegradable component in organic matter under controlled conditions. The use of manure will assist in inoculating the compost, absorb liquid, prevent savaging, and enable a porous environment to maintain oxygen levels allowing microbial activity. This process requires a large amount of carbon such as sawdust to be successful. (Edgerton, 2008)

Bioenergy from Manure

There are four main technologies, and variances of these, that have the potential for the commercial conversion of the energy in manure to usable energy. The important thing to remember is how that energy can be utilised and its cost of production.

Anaerobic digesters

Manure is mixed with water and placed in a closed space where microbial decomposition of organic matter in the absence of oxygen produces biogas, consisting of methane CH_4, carbon dioxide $C0_2$ and trace elements – water and hydrogen sulphide H_2S. Australian feedlots generally collect manure between feeding periods 70-120 days, in this time much of the readily digestible organic material has already broken down. The remaining organic material may take months to convert to biogas – requiring large reactors. Furthermore to use a low solid AD process, the feedlot will need to dilute the manure with hundreds of megalitres of fresh water. (Edgerton, 2008)

Free stall dairy and piggery operations, with pens and alleys flushed daily, work well with digesters as the manure does not get mixed with dirt or stones and can be pumped to a digester while fresh. There are three main designs for farm based digesters; covered anaerobic lagoon, plug flow, and complete mix (continually stirred). The latter two being preferred for their ability to handle solids in dairy and pig manure.

The current capital cost range for complete digester systems is estimated at $1,000 to $2,000 per cow depending on herd size with the cost to maintain an engine generator set being 1-2 cents per kwh of electricity produced. Published digester economic assessments tend to show that the most successful digesters are those that have generated added value from separated manure fibre, charged tipping fees from off farm wastes, had a nearby high value use for electricity or biogas. Electricity sales alone are not usually enough to cover costs. (Lazarus, 2010)

A project designed to process solid feedlot manure to produce electricity has been established in Alberta, Canada. The integrated manure utilisation system is processing manure from Highland Feeders, a 36,000 head capacity feedlot with the initial pilot plant designed to handle waste from approximately 7,500 head to generate 14,000 Megawatts of electricity and 13,000 tons of bio-fertiliser. This project is a co-government and private investment of $7.9 million and is seen as a model for feedlots, however the high capital costs and water usage combined with highly technical operating requirements has limited its adoption at this stage.

Pyrolysis

This is a thermo-chemical process at a very high temperature in the absence of oxygen used to convert manure to a gas or liquid fuel and bio char. This technology is yet to be commercialised and would require a very complicated plant, but has the potential to be a more cost effective carbon capture than either geo-sequestration or agri-forestry. Agri-char could also have significant agronomic benefits.

Gasification

Gasifiers convert materials with high organic content, such as manure, at high temperature in an oxygen limited environment, to produce a gas capable of burning in a boiler or reciprocating engine. The process occurs in a closed reactor known as a gasifier at a temperature of 260 degrees C and is completed when the temperature reaches 1,150 C. Depending on the biomass, the producer gas maybe accompanied by moisture, particulates in the form of fine ash, and tars which must be removed before the producer gas can be used as a fuel. The energy required to sustain the reaction is generated by the complete combustion of portions of the biomass fuel, fed to the gasifier when combined with waste heat use, the process efficiency can exceed 75%.

Incineration

Incineration or direct combustion of dried manure is one of the oldest manure-to-energy practices that have been widely used across the world. Most of the existing technologies range from small fire box boilers to larger moving grate beds. All however require modification to feedlot manure through briquetting or pelletising, along with the addition of a carbon source. Briquetting enables the removal of moisture along with binding with other organic compounds such as sawdust and straw. This added process increases considerably the cost of the fuel being burnt, reducing its commercial application in a feedlot manure situation.

Feedlot Manure as a fuel

To determine the heating value of feedlot manure depends on its overall composition, however an estimate can be made if you know it's (a) ash content (% on a dry basis) and (b) the moisture content (% on a wet basis). Feedlot manure that has been stripped of all its ash and thoroughly dried has a "higher heating value", or maximum fuel value of about 3,865 kj/kg (8,500btu/lb). Ash and moisture reduce that value proportionally. In general, the simplest formula for establishing fuel value of feedlot manure on a "as-is" basis is HHV (btu/lb)=0.85x(100-ash%) x (100 x moisture%) thus a manure sample with 20% moisture (wet basis) and 35% ash (dry basis) would have a higher heating value of approximately 4420btu/lb = 0.85 x 65 x 80. (www.extension.org, 2008)

According to JBS Five Rivers Cattle Feeding one ton (907kg) contains:

- 204kg of ash
- 7380Mj (7mill Btu) of energy
- Equivalent energy of 217lts of diesel
- Equivalent energy of 295 lts of propane
- Energy conversion of 2.05Mw/h of power

For the purposes of conversion: 1 btu/lb = 2.326kj/kg = 0.55 kcal/kg

Determining the energy cost of different fuels

The gross calorific value of different fuels must be established for comparisons to be made.

Fuel	Mj/kg	Cost
Diesel	44.8	2.37c/Mj
Butane	49.5	2.01c/Mj
Propane	50.35	2.16c/Mj
Coal	28-31	0.86c/Mj
Manure	10-12	0.10c/Mj

1. Calorific values (www.engineeringtoolbox.com, 2011)

2. Smithfield Benchmarking Data, Delivery Quotations 2008-2010

3. Average $10 tonne sale price on Smithfield manure.

Emissions

Martin Teasdale from the Australian Greenhouse Office stated that; Feedlot cattle contribute about 2% of national livestock emissions and about 0.26% of the national greenhouse gas emissions in 2001. These emissions consist approximately;

- Enteric (digestive) methane 66.5%
- Methane from manure 1.2%
- Nitrous oxide from manure 32.3%

Teasdale identified greenhouse emission reduction opportunities for agriculture in general, including,

- Reducing energy use.
- Reducing livestock methane emissions
- Manure management
- Use of biogas

Chen 2009 stated that of the national beef cattle population of 28.8 million, around 680,000 are managed in feedlots at any time, generating approximately 3.5% of livestock GHG emissions or 0.4% of total emissions.

However Muir, Chen, Rowell and Hill study in 2011 demonstrated that the current Australian methodology for estimating enteric emissions from feedlot cattle is over-estimating emissions. The models used in national inventories were developed in the 1960's and 1970's from short duration metabolism experiments and not for the purpose of greenhouse inventories. More importantly, these equations were developed based on dairy cattle fed diets which differ significantly from today's feedlot cattle rations.

Reduction of emissions from enteric methane has involved three main strategies;

- Rumen modifiers – which include Ionophores (eg Rumensin), Buffers and bentonite, Salt (increasing flow rate).
- Modifying the feed – increase digestibility (steam flaking), high starch/low fibre diets, inclusion of dietary fats.

- Altering the animal – age, body weight, genetics, hormonal implants (giving higher feed conversion efficiency and weight gain), Beta Agonists (increasing end-point yields).

Manure management; currently most cattle manure from feedlots is applied in its raw state to nearby fields, which may lead to environmental problems such as nitrate leaching to ground water and Phosphorous runoff to surface water. Composting allows manure to be transported further and applied to a greater area, however composting may solve one environmental issue (protection of water quality) while creating another one (increasing GHG emissions).

Composting requires turning (aeration) into windrows but as Hao et al 2002 concluded, the total emissions in terms of CH_4 and CO_2 – carbon equivalent, were 240kg/t (unturned) and 410kg/t (aerated). Higher GHG emissions for the active than passive aeration treatment were due to the effect of turning on biological activity.

Australian parliament is about to pass the Carbon Farming Initiative, this bill covers two classes of projects; - emissions avoidance projects and sequestration offsets projects. Of the avoidance projects, there is two of most interest to the feedlot industry; reducing methane emissions from livestock and reducing methane/ nitrous oxide emissions from manure. In terms of sequestration offsets, the land application of manure (or by-products from the combustion/gasification of manure) to store carbon holds the most potential as non-Kyoto credits. (Australian Lot Feeders Association, 2011 Aug)

At a carbon price of $23/t and using the total emissions from unturned manure of 240kg/t, a 9,000t/manure/year fed gasifier required to generate enough steam for a 20,000 head feedlot would create $49,680 of carbon emission avoidance.

Findings

U.S.A

ISCAT – Denver

Ravi Malhotra: Executive Director

ISCAT are in the process of completing a manure biomass briquette research project designed to discover the optimal composition and properties for briquettes to yield the maximum energy output and handling ability.

At the moment research and feasibility are being conducted with two feedlots both approximately 50,000 head in size. Briquette manufacture is conducted by FOREST Energy Corp in Sholow Arizona.

Various compositions from 40% to 60% manure combined with straw have been analysed for calorific value as well as sulphur, carbon and nitrogen content. Assessment of handling characteristics has also been conducted to ascertain the commercial practicalities for bagging, transport and application as both fuel and fertiliser.

Ordinarily feedlot manure has a heating value of around 5100 Btu/lb; with the addition of 50% straw the value can be increased to around 6800 Btu/lb as well as increasing its binding characteristics. For the process of gasification to occur manure requires a burn temperature of around 4270 degrees C, the addition of straw brings this temperature down to 200-315 degrees C making the process more energy efficient. Thus far there is no commercial gasification system for feedlot manure using the traditional fluidised bed grate system, however work is being done by the University of California Davis Campus as the energy costs and environmental constraints in that state gives more encouragement for solutions to be developed for manure disposal. Ravi's view is that in general the costs involved in the extraction of energy from feedlot manure is not at a stage that would make this system viable using traditional gasification systems.

Pelletising is all about densification to allow logistics and handling to be commercially viable, currently manure/ straw pellets are sold in the horticulture and gardener market at around $150 to $160 U.S tonne FOB through Wal-Mart

Colorado

Harshenviro Bob Brown – President

Harsh industries are a diverse manufacturing and engineering firm who have based their operation around the manufacture of agricultural equipment specialising in the feedlot industry. They have diversified out into many other products from hydraulic rams, scale load cells, and many other products as diverse as signage for Whole Foods to guns and aircraft parts.

Of interest to me was the prototype manure gasifier and the building of their first commercial continuous flow manure gasifier. The design has been developed under patent in conjunction with David Brooks who after a background in human cremation developed more advanced incineration systems used to dispose of the many cattle carcases during the BSE outbreak in England. It was at this point he realised that at a certain burn temperature the hot gases produced perpetuated a gasification process that could be used in a continuous burn that could be applied to any organic matter with a high enough level of thermal capacity such as manure. David Brooks along with JBS Swift – the largest feedlot operator and processor in the world, then approached Harsh to develop the prototype from which they are now building the first commercial unit based on the hot hearth concept. This unit will burn around 1 tonne of feedlot manure per hour supplying enough heat to drive a 250 horse power boiler delivering 3,000kg of steam per hour. The amount of steam produced by this unit would be enough to run the steam flaked grain processing of a 20,000 head feedlots. The unit is estimated to be able to maintain gasification of manure at a burn temperature of 760-870 degrees C at no more than 505 moisture and no less than 3500 btu/lb energy value. The calorific value of the manure will vary with the amount of silica (dirt) but clean manure can contain up to 8500 btu/lb with averages around 5100 btu/lb. Particle size needs to be no more than a tennis ball size.

First commercial unit under construction (Photo: Don Madden) The unit will consist of a modular 32 slow screw bed inside a refractory at a cost of around $450,000 U.S. In addition a single stage water tube boiler with control system along with a size standardising manure handling feed would be necessary. The unit would use around 9,000 tonne of manure per year and run 24 hours per day as it takes over 24 hours to reach burn temperature. Ongoing development will be around the practical operation of the boiler and steam generation which is the first productive output of the burner.

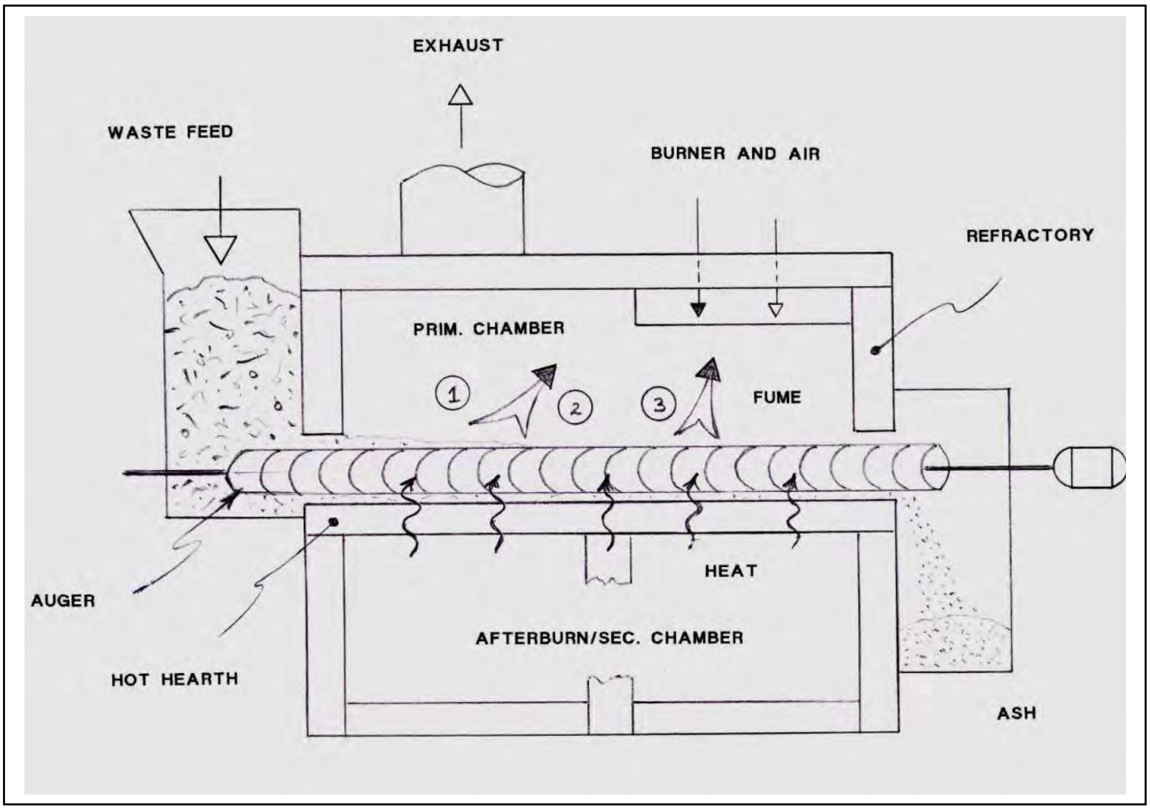
The steam production is however only a part of the designs overall potential. The 250 horse power required to generate enough steam to power the grain flaking requirements of an average 20,000 head feedlot model would only require less than 50% of the energy output from the unit running 24/7. The heat produced when not required by the boiler could power a generator capable of 1Mw of capacity. Steam generators capable of this would be costly and a substantial feed-in tariff would be required to justify the huge capital expense ($660k U.S) and running costs associated with running the plant at night.

The ash produced depends on the amount of silica (dirt) present in the manure, it can range from 10%-30% of the original dry matter weight of the manure. The heat from the ash could be used to heat the boilers feed water requirements via tubing in a jacket ash hopper design. The ash itself is high in sulphur but stable, and will have high value as a soil conditioner in highly acidic soils. Other uses proposed include fly ash in construction materials such as concrete and road base.

The burn temperature is high enough for use in the disposal of animal carcases and other feedlot wastes currently used in composts. JBS Swift is interested in using a product called DAFF which is the scum skimmed off anaerobic ponds at their meat processing plants. This product consisting of hair, blood and fat has a heating value of up to 14,000 Btu/lb. Their plant at Greeley produces up to 15,000 lb/day which is sufficient energy value to heat 1.5million gallons of hot water per day; this could then be circulated in their ponds during winter maintaining their aerobic processes as well as supply hot wash down water for the entire plant.

This is the only gasification system being developed specifically for the production of energy from dry feedlot manure and its uniqueness is centred on the continuous flow design that enables it to handle the low energy and contaminated feedstock that is produced in the feedlot situation. Continuing development and refinement by Harsh will result from trials conducted at JBS Swift feedlot at Kersley this year.

Figure 5: Basic sketch of auger system (Courtesy R Brown Harsh Industries)



Kansas

Dodge City Roto-mix: Rod Nier C.E.O,

Roto-mix are a specialised feeder bin manufacturing company that have been making a unique design of truck mounted and trailer feed delivering mixers as well as manure spreaders and digital weighing systems.

Sharing ideas and giving feedback on the design and improvement of the mixers is always beneficial as these units are the most used in Australia and the feedback is most welcome.

Discussion on the design of new scale indicators centred on the addition of a GPS navigation function to the scale head which had previously been under patent and not available for export. Input into the functionality and programming features of the new design were had with scales manager Myron Ricke.

Rod expressed interest in the possibility of manufacturing a manure burner and will be monitoring the developments at Harshenviro as his knowledge of feedlot processes and requirements are necessary in any new equipment design.

Winters Feedyard

Ken Winters Principle

It was a pleasure to meet Ken as he has been one of the most respected cattlemen in Dodge for many years. Operating several sale barns in Kansas as well as Oklahoma the Winters family also operate farming and feeding operations.

The feedlot has a capacity of around 30,000 head, it was a very tidy, straight forward operation minimising over-capitalisation but operating efficiently. The constraints of being on the city limits, along with three other adjacent feedlots, ensure that the environmental management of manure, effluent and odour is first rate.

Discussion of cattle marketing, feedlot management and commodities were had with Ken and although he appreciates the need for good manure management practices, the idea of utilising it for production of energy prompted the advice that some things are just meant to be thrown on the ground.

Wichita

Alternative Energy Solutions: Dave Daniels Manager

AES is a subsidiary of Wichita Burner, a boiler manufacturer. Their role is to develop alternative energy generation systems and their commercialisation.

They have a commercially functional biomass gasification unit capable of using feedlot manure as a fuel source. The unit is modular and the company can provide a fully automatic turn-key set up for around $600k. They have over 700 of these units around the world but are yet to have been commissioned to install one at a feedlots which is indicative of the lack of interest shown by feedlots across the mid-west. Although Dave expects this will change over the next two or more years as environmental constraints and not energy cost is expected to be the main driver.

Although I was unable to see cattle manure being burnt, they are developing a unit to utilise horse manure. Other units are going to small scale biomass projects mainly utilising wood waste products to heat community buildings. These models are moving grate updraft gasifiers and have limited potential as the fuel source needs to be substantial and ongoing, and the energy usage immediate. The ability to reduce the burn during off peak times as is faced by many other generation systems is still work in progress, with any steam powered generation infrastructure dependant on the economy of scale which must be large enough to match capital cost to volume of fuel available.

Modular Bio-mass Gasifier Photo: Don Madden

Touring some of the many blocks that are owned or leased by the family, the operation consists of 1,600 acres of wheat pasture and 1,000 acres of grass pasture, the cattle are taken off the wheat in March allowing it to seed and harvested at around 50 bushels/acre. Mineral rights sold for oil exploration also provide significant farm income with $500/acre per year for the 3 year exploration lease and 3/16 of royalties from any production. This contrast to property rights in Australia is a key difference in the relationship between the gas exploration and extraction industries in both our countries. Gas is seen as a huge priority in the USA's quest for energy self-reliance with exploration for both natural gas and coal seam methane being conducted on a massive scale through-out the country.

.

Enid

Johnston Enterprises: J.L "Butch"Meibergen II

Johnston's are the largest independent grain traders in Oklahoma with 24 grain elevators and 2 grain terminals consisting of 18 million bushel capacity in Enid and a 2 million capacity rail facility in Shaddock. Other interests include a shipping port in Muskogee to utilize the vast waterways and a seed company that sells all traditional crops and also pasture, turf, sports fields and wild flowers. They produce and market the largest volume of cold climate Bermuda grass in the U.S.

Butch Meibergen who is the president and C.E.O of Johnston Grain Company, a 50 million bushel/year facility based in Enid Oklahoma expressed to me his doubts that the U.S grain production system would never be able to sustain supply to fulfil a 15% mandate and that speculative bidding on grain markets is being driven by ethanol plants trying to secure stocks to satisfy demand from an increasing mandate.

Tours of his trading floor, offices and grain handling facilities were truly inspiring as his friendliness exuded throughout his workforce which was considerable. All the staff were very interested in the goings on in Australia particularly the impact of the flood on grain production and the sale of large volumes of feed wheat into China, the trading floor was very specialised in regions and particular commodities.

Butch left me with a few things to ponder on including: his view that the market will be neutral to bearish on corn futures, he would never invest in grain to ethanol as it is operating in a artificial market that will be at the mercy of political will, there will be continuing problems faced with mutations and weed resistance in G.M crops, and the continued advancement of heat and drought tolerant crops will continue to reduce yields.

Oklahoma State University

Dr Chris Richards Extension and research Beef cattle specialist.

Chris revealed some of the research currently being conducted by OSU, including a spayed heifer trial, algal bi-product feeding trials for anti-oxidant traits in meat to counter the effects of distiller's grains on fatty acid profiles. Also being looked at are the feedlot behaviour and temperature monitoring of livestock using rumen temperature boluses, working with data recovery and methods to automate protocol for health management systems using these boluses.

Chris displayed a passion for the beef industry and shared some of his views including the difficulties that are going to be faced by the "natural beef market segment" including a conversion loss per carcase of $40-$60 and a backgrounding loss of $20/head even with the use of Rumensin and Bovatec. He also alluded to the difficulties that come with maintaining premiums that are needed to support integrated supply chain systems which have appeared to have failed in the past. The organic trade relies on small 10 to 15 head herds that are supplemented by lifestyle culture without inclusion of true cost of production. As yet there is no regulatory framework that supports auditing and accountability of these production systems. Also discussed was the inability of cellulosic ethanol groups to garner political support for next generation ethanol plants subsidies as opposed to the powerful corn grower groups of the mid-west. Adding to that the sheer logistical inefficiency of this type of system makes it a no goer according to him.

Arjay Kumer an assistant professor in bio systems and agricultural engineering works mainly on the heavily researched cellulosic biofuel industry development gave the assessment that gasification of feedlot manure was difficult and that down draft fluidised bed systems may give enough energy to heat water but may lack the horse power needed for steam generation. The limitations due to high ash content is something that existing grate bed burner systems would encounter continued to be of concern from an engineering perspective.

Oklahoma Feedlots

Visiting feedlot operations such as Wheeler Bros. at Watonga and Buffalo feeders at Buffalo reinforced the opinion that interest in alternative fuel from manure is not on the radar in so far as its place in the total energy cycle is not a cost driver and priorities lay in grain purchasing and cattle performance.

Environmental management concerns were not as high a concern as feedlots in Kansas or Texas with natural gas availability and price quite competitive making the challenge of adopting a radical change to energy for steam systems less interesting.

Amarillo Texas

Dr Ken Casey Agrilife Research and Extension Centre

Agrilife is an extension and research arm of Texas A&M University providing a wide range of services throughout Texas, across a wide range of Agriculture. The areas of expertise in Amarillo revolve around wheat and large ruminant.

Amarillo is the cattle feeding capital of the world with 42% of the fed beef in the U.S within a 200 mile radius of the city. Ken who is an Australian has been working in the Panhandle for 8 years on air quality engineering, the biggest perceived problem by producers in the area as a combination of low rainfall – 17 inches (410mm) and an annual 5 million tons of manure contribute to a fine particulate that creates a haze across the region.

Emissions are federally regulated with emissions above certain levels to be reported. These regulations which were originally placed to monitor manufacturing industries are being applied to large scale agricultural enterprises by environmental advocacy groups which are little more than fronts for litigation law firms who have profited from many out of court settlements. Agrilife have been developing defensible scientific data to counter the often out-dated and poorly researched assumptions previously used in the court of law.

Unlike Australia there seems to be little emphasis on effluent and water quality monitoring as it is not seen as big an issue as air quality and emissions. Ken also expressed serious doubts about the viability of the ethanol industry citing most viable operations being picked up at low values after initial bankruptcy and then only able to operate with the three market buffers of artificial demand – 10 to 15% mandate, government funded producer tariffs and protection from imports.

Agrilife

Dr Brent Auvermann.

Brent's work has been concentrated on manure management and the utilisation of this resource as an energy source. Along with Dr John Sweeten, who unfortunately I was unable to meet with, have researched many possibilities including co-firing coal fired electrical generation and providing steam production for an ethanol plant.

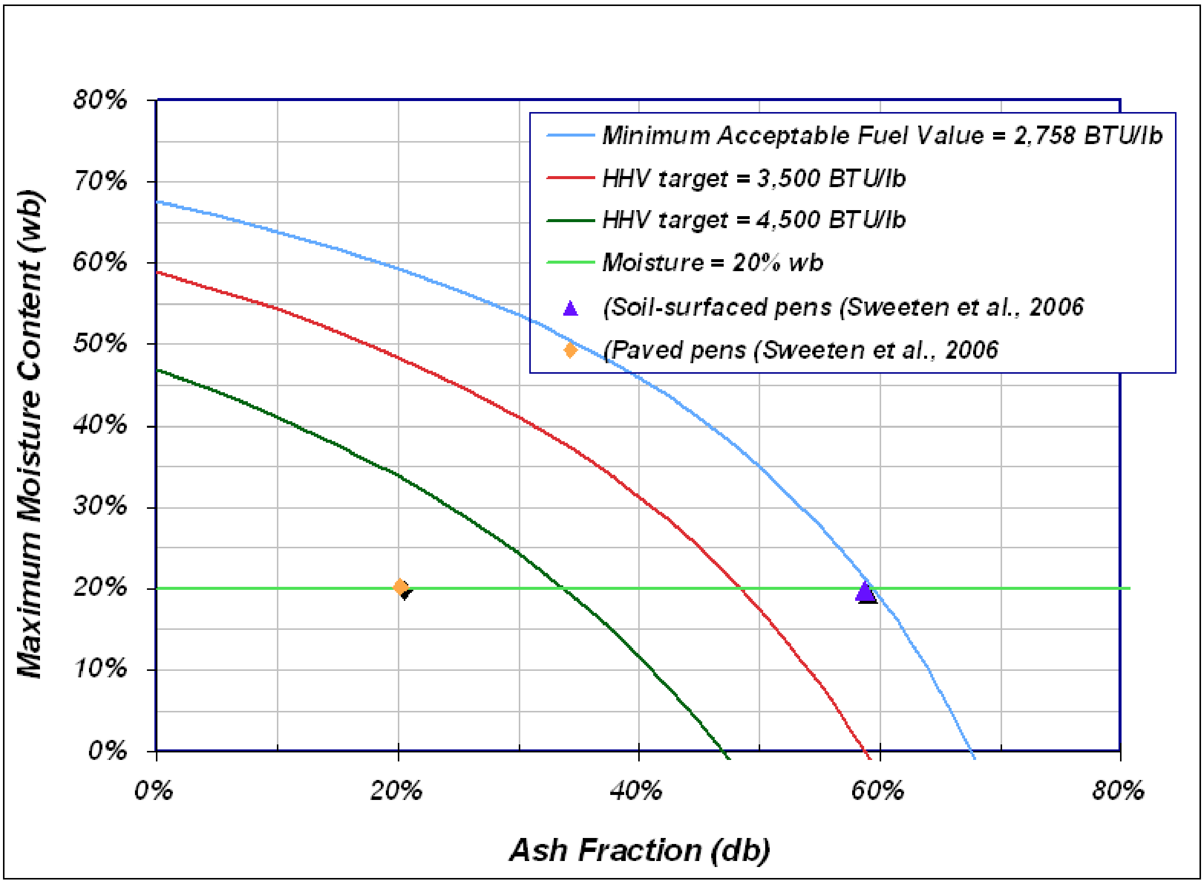
The management of manure especially in the area around Amarillo is a growing problem as a reduction in water availability from the Ogallala aquifer is beginning to reduce areas of cropping which has been the traditional user of manure as fertiliser. Manure has an economic value relative to its distance and cost of transport to arable cropping areas - with a reduction of these areas many feedlots are now stockpiling vast mountains of manure. Therefore much research has gone into projects to utilise this energy source with the most promising over the past few years being Panda Energy – an ethanol plant who were going to utilise the manure for steam generation in their ethanol process. However Panda went into receivership and have subsequently been bought out by a subsidiary of Walmart who will not proceed with the project without renewable incentives for the use of manure. There appears to be a rule of thumb that ethanol plants become viable only when capital cost has been reduced after chapter 17 insolvency proceedings and subsequent purchases by the second or third operator and the three pillars of tariff rebate, mandated demand and protection from imports are maintained by the federal government.

Models of gasification of manure for steam production in feedlots have not been adopted due to the low cost of natural gas and a general resistance to change within the cattle feeding industry. It was noted that many operators still have vivid memories of renewable energy projects that had a fleeting surge during the energy crisis of the mid-seventies and believe market forces will maintain traditional hydro-carbon's at competitive levels going forward.

Other areas covered with Brent included the possibilities in phosphorous extraction from manure through incineration and chemical mobilisation, ash pavement of feedlot pens to improve energy recovery and management, and economics of composting and its markets.

Study by Agilife on the burning properties of manure as it relates to ash and moisture content, and also to its method of recovery from different pen surfaces has been conducted over many years of research.

Figure 6: Manure Energy Value Curve (Chart Courtesy B Auvermann Texas AgriLife2008)



Asia

Beef consumption across the world on a per capita basis has not shown any dramatic increase over the last 10 years, due to its limited supply and price. However protein intake generally has increased mainly due to the increased wealth of the developing economies of Asia; this protein market has and will continue to be met by the intensification of poultry and pork industries. The advantage these operations have over the beef industries is their ability to operate without the need for large rangeland and transport system requirements, however their need for grain will continue to generate fierce competition for dwindling world stocks of grain amongst both the livestock industry and biofuel industry.

Table 3. Beef Consumption by Country Source USDA Foreign Agricultural Services 2011

Beef and Veal: Per Capita Consumption (CWE) Selected Countries

Kilograms Per Person

	2007	2008	2009	2010	Oct 2011
Per Capita Consumption					
Argentina	69.2	67.5	66.7	55.8	54.0
Australia	34.7	35.0	35.0	35.3	34.2
Brazil	36.8	36.9	37.1	37.8	37.6
Canada	32.4	31.2	30.3	29.6	29.2
Chile	23.3	21.9	22.5	23.6	25.9
China	4.6	4.6	4.3	4.1	4.0
Colombia	16.7	15.2	18.0	19.2	19.0
EU-27	17.7	17.0	16.8	16.6	16.6
Egypt	8.7	6.7	6.8	7.7	6.6
Hong Kong	15.0	18.9	24.0	23.8	32.3
India	1.5	1.6	1.6	1.6	1.8
Iran	7.3	7.7	7.6	9.8	10.0
Japan	9.3	9.2	9.5	9.7	9.6
Kazakhstan	27.1	27.3	26.7	26.8	26.5
Korea, South	10.8	11.1	11.3	12.5	12.9
Mexico	17.9	18.3	17.6	17.2	17.8
New Zealand	29.8	29.5	28.5	29.2	28.0
Pakistan	8.1	8.1	8.4	8.4	8.1
Paraguay	26.2	31.9	35.3	35.6	37.0
Philippines	3.9	4.0	3.5	3.7	3.9
Russia	17.3	18.6	16.8	16.6	15.7
South Africa	14.5	14.0	14.1	14.0	14.1
Taiwan	4.7	4.8	5.2	6.0	6.4
Ukraine	10.9	10.5	8.4	8.5	8.4
United States	42.6	41.0	39.8	38.8	37.4
Uruguay	51.7	50.6	58.4	62.1	53.9
Uzbekistan	20.4	21.5	21.4	21.5	21.7
Venezuela	20.8	23.1	18.8	18.2	18.8

Note: May include meat of other bovines

Indonesia

Greg Pankhurst's feedlot operation on the island of Sumatra is an excellently run operation finishing mainly Australian live export cattle for domestic consumption. The feedlot visited at Bandar Lampung is a 10,000 head facility feeding a ration of palm kernel, copra, tapioca base, dried distillers grain, soya meal, corn silage, palm oil, rice straw and green chop. There is very little grain fed in the ration with cost of gain around $1.75 to $1.85 AU which is very competitive with anything in Australia.

The manure produced by the feedlot is of extremely high quality due to the feedlot being under cover, paved and the use of coconut husk and sawdust bedding. Cleaning of the pens is conducted every 4 days producing 300t/day of manure at around 20% dry matter. The manure has to be constantly sprayed in the early stages of composting to prevent fly larvae blooms, after composting the manure is sieved and bagged to be sold for around $60/t AU.

Greg expressed interest in energy production from the manure, which due to its high organic matter content (bedding materials) and freedom from any contaminants (paved pens) would yield a high energy value on a dry matter basis. The moisture of the product (80%) would lend itself to an anaerobic digestion model rather than a gasification model for energy production.

Riksan Aripin, the director of Domus, which has set up one of the many palm oil processing plants that are emerging in Indonesia, demonstrated the confidence of investing in this rapidly expanding agricultural based industry. Riksan and Greg would like to investigate the synergy of utilising the feedlot manure to provide steam for the oil extraction process; however logistic challenges and the moisture content of the manure would limit its application in this situation. Palm oil production is a relatively lucrative enterprise for most small landholders in the Sumatran provinces with the average farmer able to harvest 7ltrs/day per tree with a 30 tree plantation returning the equivalent of $20 AU per day.

Photo: Greg Pankhurst, Author and Operations Manager (Juang Jaya Feedlot)

Elders feedlot in the same area has a capacity of 4500 head feeding the similar Australian imports, and like Greg Pankhurst's operation there is a commitment to utilize locally produced cattle (up to 10%) that struggle to perform at the same productivity as the imports. The rations are similar utilising low cost co-products converted at around 9:1 on an as fed basis by the cattle. The feeding lengths are being are being extended due the import restrictions with days on feed extended from 70 to 100 days, this is assisted by aggressive HGP programs and the use of beta-agonists.

The area received in excess of 3.5 meters of rainfall per year necessitating a pen cleaning regime of every 3 days with manure and effluent pumped onto surrounding fields which creates problems in the low lying surrounds.

Europe

Berlin

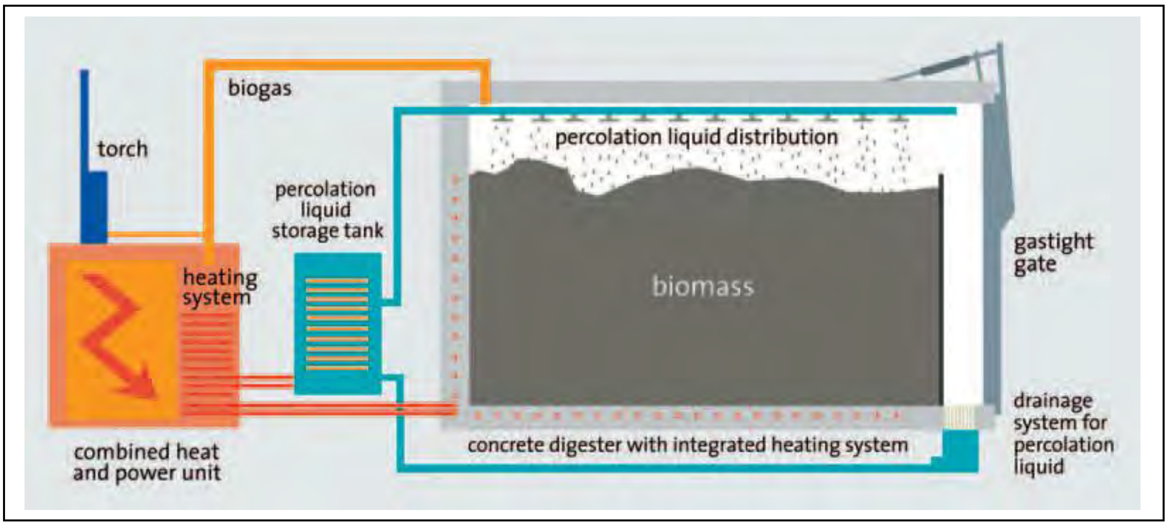
Peter Lutz Bekon industries

As most intensive animal production throughout Europe is centred around pigs, dairy and chicken production, the manure to energy systems are mostly designed for wet manures best suited to aerobic digestion or wet fermentation.

Process ability of solid wastes such as feedlot manure is limited. Peter Lutz from Bekon in Munich, Germany has patented a batch process dry fermentation method capable of handling agricultural waste up to 50% dry matter. Methane gas yields are similar to conventional liquid fermentation systems without the need for complex liquid handling systems. The system is a series of airtight compartments that are temperature controlled with reticulation of the treated percolation liquid repeatedly sprayed over the organic matter; dosing with lime to maintain Ph is computer controlled as is moisture and temperature.

The gas production from the system can be regulated by adjusting the temperature within the digester, it is then dried, measured for quality and volume (about 60% methane), then regulated into a combined heat and power unit. These systems are mostly designed for co-generation of electricity to be fed into the power grid at generous renewable tariffs. Direct burning of natural gas for a boiler would require further processing of the gas which may be expensive. The system produces a low moisture substrate with a high fertilizer value which could reduce its transportable range and cost. Capital costs for processing 10, 000 to 20, 000t of feedlot manure would however range from \$3 – 4 million. That and the fact that feedlot manure in the Australian state would generally exceed 50% dry matter makes the system less than ideal for a cattle feedlot operation

Figure 7: Dry Fermentation system (Bekon)



Recommendations

Commodity prices for grain and energy now seem inexplicitly linked, as grain is the greatest energy input into the feedlot. The ability of any operation to convert its energy (feed conversion efficiency) into an output (carcase) requires more energy inputs (fuel for steam flaking).

Utilisation of feedlot manure to provide this extra energy input needs to be commercial as existing processes to extract energy from manure have a high capital cost and require much expertise to operate. As existing fuel costs are only a small input in the overall cattle feeding operation it does not receive a high priority however other management concerns and opportunities may drive its adoption.

- High grain prices make steam flaking of grain a necessity to ensure good feed conversion and weight gain.
- Manure has a usable heating value and traditional disposal methods are limited in some areas to logistic and environmental restrictions.
- The dry nature of feedlot manure makes it ill-suited to anaerobic digestion processes better equipped for wet manures.
- High silica and ash content in feedlot manure ensures existing biomass gasifiers may be of limited use.
- Pyrolysis and gasification models designed to produce fuel or electrical power are at present non-economic on a cost basis.
- Gasifiers specifically designed to handle feedlot manure need to be developed with turn-key commercialisation if adoption is going to happen.

- Opportunities exist for carbon abatement in Australia through using gasifiers in the management of manure.

- The utilization of excess energy produced by a gasifier when not needed by the feed manufacture process has the potential to be fed into the main stream power supply.

- The value of emission avoidance by utilising manure that would otherwise be composting are around $5.52/t if approved under the carbon farming initiative with a carbon price of $23 /t.

- Cost savings would be in the area of $6 per head due to replacement of boiler fuel for steam flaking. (This includes the cost of the manure.)

References

Australian Bureau of Agricultural Resource Economics, A. (2010). *World Grain Forecasts 2010.*

Australian Lot Feeders Association, A. (2011 Aug). *ALFA.*

CME, G. (Vol 9 No.138 July 2011). *Daily Livestock Report.* CME Group.

Condon, J. (2011). Beef Central News. *Beef Central News*.

Edgerton, B. (2008). *ALFA Beefex.* Gold Coast, Qld Australia.

Huntington, G. B. (1997). *Starch Utilization by Ruminants: From Basics to Bunk.*

Lawrence, R. (2008). *ALFA Beefex Conference 2008*, (p. p 77). Gold Coast, Qld Australia.

Lazarus, W. F. (2010). Economics of Anaerobic Digesters for Processing Animal Manure. *University of Minnesota*.

Nutritional Services Associates, N. (2010). *Nutritional Services Associates Performance Data.* NSA.

www.engineeringtoolbox.com. (2011). *Conversions.* Engineers Toolbox.

www.extension.org. (2008). *How much fuel energy is contained in feedlot manure.* more than 70 USA universities: eXtension, interactive learning environment.

Wylie, P. (2008 Feb 2nd). *Feedlot Manure Can Provide Half Price Nutrients.* GRDC Newletter.

Interviews:

Colorado

Ravi Malhotra –Executive Director ICAST

Bob Brown – President Harsh International Inc.

Tom McDonald – Vice President of Environmental Affairs JBS Five Rivers

Matthew Jacobs – Sales Hurst Boiler and Welding Company Inc.

Kansas

Ed McNair – McNair Geothermal

Rod Neier – President Roto-Mix

Ken Winter – Principle Winter Feedyard

Dave Daniels – President Alternative Energy Solutions International Inc.

Oklahoma

Tom Fanning – Feedyard Manager Buffalo Feeders

Dr Chris Richards – Extension & research Beef Cattle Specialist OSU

Ajay Kumar – Assistant Professor OSU

J.L (Butch) Meibergen - President and CEO W.B Johnston Grain Company

Austin Lafferty – Wheeler Brothers Grains

Texas

Dr Brent Auvermann – Professor AgriLIFE Extension Texas A&M

Dr Ken Casey – Assistant Professor AgriLIFE Extension Texas A&M

Joe Young – Manager Integrated Beef Programs Micro Beef Technologies

China and Hong Kong

Tim O'Driscoll – Manager South Stream Seafoods

Chan Yau Man – CEO Samagen Imports

Germany

Peter Lutz – CEO Bekon Energy Technologies

Indonesia

Greg Pankhurst – Managing Director Juang Jaya

Riksan Aripin – Director Domas

Henry Wijaya – Biosecurity and Quality Pt Prima Larvae

Budiman Safari – Feedlot Manager Elders

Glossary

Ionophores – Compounds commonly fed to cattle that target rumen bacterial population and the microbial ecology of the rumen, improving feed efficiency and reducing the risks of acidosis and bloat. Includes registered trade names: Rumensin and Monensin.

Beta-agonists – Partitioning agents that shift nutrients away from fat deposition towards lean muscle growth. Includes registered trade names: Optaflexx and Zilmax.

Bovatec – Trade name for feed medication for the prevention of coccidiosis in cattle.

Cellulosic ethanol – Biofuel produced from wood, grass and non-edible plants.

Plain English Compendium Summary

Project Title:	Feedlot Energy System and the Value of Manure Gasification of feedlot manure for energy in feed manufacture
Nuffield Australia Project No.:	
Scholar:	Don Madden
Organisation:	Smithfield Feedlot
Phone:	07 41689104
Fax:	07 41689478
Email:	don@feedlot.com.au
Objectives	Investigate the use of manure as a fuel for feed manufacture in a cattle feedlot and its place in the overall feedlot energy cycle.
Background	Larger cattle feedlots use grain steam flaking in their feed manufacture - this requires large amounts of fuel to produce the steam. Beef feedlots also produce vast quantities of manure which has an energy value but can provide challenges in its disposal. There lies an opportunity for a closed loop energy system using the feedlots manure to fuel its steam flaking requirements.
Research	Conducted throughout the mid-west of the U.S.A , Visiting feedlots, equipment manufacturers, grain traders and research institutions. Research in Asia involved visiting feedlots in Indonesia and meat traders in China. Inspection of installations in Germany was also conducted.
Outcomes	Energy is still cheap and plentiful in the context of the cattle feedlot production system. Utilizing energy from manure will be driven by environmental concerns and abatement incentives. Equipment will need to be developed specific for the needs of the energy feedstock and the application of the energy. Continuous flow hot heath gasifiers appear to be the best option.
Implications	The low cost of manure as a fuel cost could increase feedlot margins with the benefit of reducing manure disposal costs. Lowering emissions through reduced methane production in composting and storing manure could generate carbon credits under the Australian Farming Initiative.