NUFFIELD FARMING SCHOLARSHIP TRUST

How Poultry Farmers can Reduce their Eco-footprint

A report on a study tour

By

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2007 scholar

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Disclaimer

This report is entirely my own work. The views and opinions expressed do not necessarily represent the views of the Nuffield Farming Scholarship Trust or those of either my previous or current employer or my sponsor. Every attempt has been made to ensure the information reported is accurate but legal and financial details are subject to change and to interpretation and should not be taken as the definitive.

Executive Summary

Reducing the Eco footprint Project.

I stress the word “eco” as oppose to “carbon” specifically because I believe that while “global warming” and “green houses gases” have become the buzz words, it is really about how we as individuals and organisations treat the environment as a whole. Our carbon footprint is only a part.

I did not intend it to be a detailed scientific study into the solutions for the poultry industry to address specific issues such as IPPC, planning consent or energy replacement, but rather an overview of a range of technologies, techniques and ideas which individuals could take forward from their own position.

Poultry farming has only been part of an evolution in a wider agricultural industry. Man’s impact on the environment in response to the need to produce food and other land based goods has helped form many of the landscape features, breeds, customs and practices we recognise today, most of which we would not recognise as being negative. There will be forever progress influenced by the pressures of the period and available technology and skills.

It is usually the scale of poultry keeping operations that influence perception on its environmental impact without realising that to produce the quantities necessary, the number of production units (the birds) are maintained somewhere, with proportionally the same impact or in some cases a greater impact. It is unrealistic to compare an aesthetically pleasant traditional, extensive, small scale operation to a highly technical intensive and large-scale unit. Evidence would indicate that the latter has the potential of being more environmentally friendly than the former. It is therefore more to do with how we manage an operation, within its own environment that determines the depth of the imprint. The impact on the environment therefore must be related to the units of production and conversely the unit of production must be valued in terms of its net environmental impact. I would not wish to denigrate these extensive systems but their value may need to reflect their true cost. We must not forget the wider environmental implications of food miles, processing, and efficiency.

A major controversy is the conflict between animal welfare and environment.

In a modern society where we have the luxury of sufficient disposable income to be able to pay for our conscience, producers are encouraged to produce poultry meat and eggs that are not the most efficient in terms of their impact on the environment. Consumer perception is often way off the mark of production methods and the poultry industry has struggled with negative publicity for years, while it is still expected to deliver an ever growing and important protein source at low cost. Unfortunately the need for bio-security and environmental control for the bird’s sake prevents public access to the majority of sites which only perpetuates the problem but it does mean that somehow the industry needs to demonstrate factually what is and can be done.

I am not suggesting that the industry should abandon its commitment to welfare, we owe it to our customers and our livestock to care for them humanely but perhaps we should put it into a more scientific perspective.

It may well be that the environment will become the dominant lobbying factor as legislation and perception priorities change. In other words once consumers are satisfied with the minimum welfare standards available for a value, they will become more concerned with the environmental impact. What we should be adopting, is a socially responsible attitude that addresses both issues.

We must also be very aware of the effects of globalisation. It is untenable to ramp up consumer expectations and certainly standards and legislation that provide “tickbox” answers to local environmental issues, when in fact all we are doing is exporting the problem elsewhere and out of our own back yard.

We must therefore develop genuine environmental solutions, demonstrate our ability and commitment to our customers and use our knowledge and expertise to encourage our colleagues and competitors to do the same.

In my study I wanted to identify the ideas, technologies and situations that would provide a stepping stone to the objectives above. I wanted to visit the extremes of the industry, concentrating mainly on the egg sector, where I had had most experience. I wanted to see the traditional systems adopted in the area from where all domesticated poultry originated; Asia. I also expected to find in that part of the world some very large operations and co-operations where the emphasis was on the production of basic foodstuff at least cost. I suspected that the environment, certainly for home production would be of secondary concern to mass production. I then wanted to compare this with the sophisticated industry in Europe, which currently leads the world with technological solutions and legislation on environment and welfare. Finally I wanted to see the operation in the USA where economies of scale is paramount but where attitudes are slightly different, although becoming similar to those in Europe.

As it turned out, I experienced a change in career part way through my travels. I was unable to travel to Asia but I did visit the USA and Europe which were probably the most significant and my new career gave me the opportunity to gain insight into the broiler sector.

In particular the systems and technologies I studied included:

- solutions and alternatives for the use and disposal of poultry waste: manure, carcasses and hatchery waste
- solutions for the production of alternative power: wind, solar, biomass, biogas
- solutions for the saving or reuse of energy: heat exchangers, low energy equipment
- solutions for the removal of particles and odours from livestock building air emissions: scrubbers, filters and bio-filters
- cooperation between different agricultural sectors and with industry

- development of scientific solutions through breeding and nutrition
- solutions to conserve or manage water

I found a range of solutions for all these issues but not a single panacea.

Managing the environmental impact is as much about geographical location as anything else. Public perception and legislation, whether it be local or national are influenced by local concerns and so there will be different solutions to the same problem in different areas. It is also very much down to the skills and ability of the producer, as to which technology to adopt, his or her own preferences and the potential for a return within the context of their own business.

My report therefore identifies what I found and gives some of the reasons behind them. The intention was to evaluate their potential and sow the seed for further investigation.

1.0 Personal

When I took up the Nuffield Scholarship I was employed as Regional Manager (south) for Noble Foods. This Company had formerly been Deans Foods and before that Daylay Foods by whom I was recruited 20 years ago.

I had been responsible for 9 Company sites across the south of England, which included pullet rearing, free range, and organic and intensive cage production. Over the years I had also been responsible for some broilers and broiler breeders. The region also included 25 farmer producers, who supplied free-range eggs under contract. I had recruited many of these farmers and helped them develop their sites from green field, to full production and then, in some cases, expansion.

My role was primarily in connection with regional farm performance, based on production and welfare KPIs but within that came the responsibility of staff, site development and maintenance. I had a role in market support, implementing the initiatives necessary to satisfy customer requirements and ensuring compliance with the necessary standards.

It was while I was undertaking my study tour that circumstances within Noble Foods changed and I accepted redundancy. I was however soon recruited by Peter Furlong, who had been an advocate of Nuffield although regretfully never a Nuffield Scholar himself. He had recently acquired the sole franchise to market all the equipment of the Vencomatic group from Holland in the UK and part of that group was Agro Supply. This part of the organisation was primarily concerned with technology for manure drying, energy recovery and development of environmental and energy efficient additions to the poultry industry. There was the opportunity to develop the business with the inclusion of any suitable technology we could find.

What are my attitudes towards the environment and why did I choose this subject?

Firstly, I think we are all guilty in some way or other of impacting on the environment and we all know that we can do better if we can be bothered. As the slogan of one of the most successful retailers in the world quotes, “every little helps.”

The real issue is, whether the effort of helping the environment has any tangible benefits to us and in what time period. It is also a matter of where we chose to place our priorities. There are however some “no brainers” and issues for which there is no excuse. The worst of these will in time be exposed by legislation or financial constriction. It is therefore down to individuals, scientists and manufacturers to develop technology, skills and systems that provide reward for good environmental management and then politicians to facilitate their implementation.

I was fortunate to have been brought up in East Africa and I took up a general agricultural education when leaving school, which gave me experience in arable, dairying and sheep. I have had the opportunity to visit production facilities within different sectors in Europe and around the UK. I was convinced that it was not a shortage of skill, entrepreneurship or enthusiasm that was the problem but more a need for understanding between sectors and non agricultural industries, to allow those skills and technologies to be shared, adapted and utilised where they had not been before.

2.0 Welfare vs. Environment

"Sustainability is a political choice, not a technical one. It's not a question of whether we can be sustainable, but whether we choose to be."

Gary Lawrence, Director of Seattle Planning Department

Throughout my study tour the debate between animal welfare and the ability to minimise our environmental impact kept resurfacing. Discussing the issue with Jeffrey Armstrong, Dean of Michigan State University, his view was that the environment was more important than welfare in the USA. At Wageningen University in Lelystad, Netherlands, Dr Marko Ruis and Dr Imke de Boer are specifically researching how best to combine the necessities of animal welfare with environmental sustainability in Europe, where welfare probably has the upper hand in terms of dictating policy. Cranfield University has recently concluded a study in which not only is poultry one of the most environmentally favourable sectors of agriculture but intensive poultry is the most sustainable within the sector.

Intensive livestock farming and especially poultry is often criticised for its poor animal welfare and environmental impact. It must however be taken in context and in terms of its contribution to the supply of food. The impact to the environment is a global issue and the well being of all animals is such that intensive systems should be viewed as a positive rather than a negative. It is not the system so much that is to blame but rather the management of those systems and the priorities the consumers place on the production methods of their food. Unilateral legislation does little to promote global improvements in either welfare or sustainability.

Welfare is a very emotive topic and certainly for the majority of consumers, based on perception. It is also the privilege of the affluent society.

The biggest contribution mankind can make to the welfare of animals is the eradication of disease and parasites. Intensive systems especially in poultry do provide more manageable controls against these issues. Farm animals seem to bear the brunt of the animal welfare lobby, when in fact the conditions of many pets should qualify for as much attention if it was as easy a target. We know we cannot ignore nor condone poor welfare and there are examples of good and bad welfare in all systems, just as there are good and bad environmental strategies. We should therefore encourage research and industry innovation that will lead to socially responsible farming methods that address both welfare and environment. Wageningen University has published a tome of a document entitled “How to House A Hen” which tries to address the issue for laying hens.

Legislation will always pander to popular demand and not always to best practice and so in Europe we are faced with the Welfare of Laying Hen Directive, which came into force in 2000. This legislated for the reduction in stocking densities in all laying systems by 2012. In 2001 the Climate Change Levy expected the industry to demonstrate a reduction of 11.5% in delivered specific energy consumption (kWh per dozen eggs) to 2010 compared with the industry’s aggregate performance for a base year. As much of the energy consumption on a poultry unit is not directly proportional to numbers the effect was a reduction in efficiency and to this day despite having had the opportunity to choose a benchmark year and cooperate as a sector, the industry is already outside its target and unlikely to meet the goal. The industry has had to purchase carbon credits to offset the shortfall.

Similarly in the broiler sector, reduced stocking densities coupled with a trend toward slower growing strains to pacify the welfare lobby has impaired efficiencies and increased directly the consumption of fossil fuels used for heating and the building floor space required to meet the same demand.

The abiding message that I gathered from both the USA and Europe was that what ever we do in an attempt to mitigate our environmental impact, even if we compromise our objective in favour of welfare or production, we should do so only on the basis of sound science. We must not blindly embark on strategies that do not deliver net gains, even if they achieve some short-term objectives. Best environmental practice therefore should be measured against units of output (impact / doz eggs or impact / kg meat) and should be calculated on the whole food train from grain to egg / meat to customer.

3.0 Study Objectives

These were:

- to investigate the various technologies currently and potentially available
- to evaluate them in the context of how they could be applied to poultry producers in the UK
- to identify the key technologies that had the most potential

The aim of my study was to visit three contrasting societies.

The USA where I expected to find large scale operations geared to efficiency of production and unit cost with minimal environmental legislative burden.

Germany and Holland where the intensity of livestock relative to population and land was at its greatest and where legislation and technology had encouraged the most dynamic improvements in environmental technology.

China where I wanted to find the extremes of both primitive production methods in which" necessity was the mother of invention" and where the culture was more entwined with the local environment. I also expected to find examples of cooperation between large operations and different sectors, enterprises or communities only likely to be possible where state intervention had occurred albeit for sound environmental reasons. *Unfortunately due to a change in my circumstances I did not manage to complete this part of the tour.*

The report is intended to be a summary of the technologies I looked at with examples. I could not investigate every technology and could only evaluate the technology based on the information provided. It was intended that producers and poultry organizations would be stimulated to investigate the merits of each technology for their own circumstances.

4.0 USA and Europe

4.1 USA

Despite accusations that the USA is not serious about the environment, my visits concluded that in fact they are more concerned with the environment than with welfare. Different states have different priorities, with California probably the most welfare conscious, while states on the east coast like Delaware certainly concentrating on environmental protection. Welfare is becoming more relevant and non cage systems (not necessarily free range) are growing at about 100% per year but still only represents about 1-2% of the market.

Their concern with the environmental impact of intensive livestock units, revolved around nitrate and phosphate levels in water and emissions to the atmosphere of methane, ammonia dust and odour. Poultry has far less relevance than pigs and dairy cows. This is all to do with the nature of the manure; slurry versus dry.

The Americans have come to expect cheap food and they accept the efficiencies brought on by economies of scale. They have a more realistic approach to the production of their food than we do in Europe and they have the ability to deconstruct the concepts of their methods of production. This allows for the consumer still to choose what they want without the need for legislation.

An example of the difference in approach was a dairy farm in Michigan with 3500 cows plus young stock, all zero grazed and indoors 365 days of the year, in environmentally controlled buildings and 23 hrs/day milking. To us this is “factory” dairy farming, yet the farm can afford to support a full time Visitor Manager with a 52-seater coach that operates up to 7 visits per day through the farm. The American public seem to accept and support it and teach their children about it.

Likewise an organic egg production unit in Michigan contained 120,000 birds in what we term a “barn egg” system stocked at 8.5 birds/m². The limit in the EU is 3000, which has to be free range on organic land and at a maximum 6 birds/m². The birds in the US were fed a 100% organic diet but the customers were looking for eggs, free from additives and chemicals, not necessarily eggs that had been produced in a system with any number of bolt- on standards. In neither of these cases was welfare ignored but the perspective was different.

There is a general fear of the encroachment of European style legislation on welfare and environment creeping into the US legislator. I felt and they hoped that with the diversity of climates, cultures, geography and populations and the fact that individual states develop their own laws, that it is best to allow the industry to adopt the best practice based on the fundamentals of energy costs, feed costs and market.

4.2 Europe

Here of course, as in the UK, welfare has a higher priority but nevertheless there was a more pragmatic approach to poultry production. Barn egg as oppose to free range has more market share and even free range can operate with acceptability to different standards than in the UK. They of course, have to abide by the same internal stocking density and minimum compliance of the Welfare Directive.

The real difference in Germany and Holland is that they have the most forward thinking and radical environmental policies. I suspect this is partly driven by their tradition of small family farms, which are not the main income source. It has meant the highest density of poultry anywhere in the world, and units have established themselves in very close proximity to non-agricultural dwellings. People don't seem to mind living next to an intensive poultry unit provided it doesn't smell, make a noise or otherwise create a problem. This is where technology has provided the solutions. Even without these problems we have a very "NIMBY" culture in the UK.

The drive toward sustainable energy has been inspiring but demonstrates that it requires national stimulation that would not come from the market alone. I suspect this policy will come to prove its worth in due course although whether Europe will maintain its technological advantage once the market forces drive China and the USA to develop their own technology, is unknown.

I was suspicious that legislation was very much driven by a desire to appease popular demand across Europe which has nearly as much population and geographical diversity as the USA but a more federal legislation system.

5.0 Manure Technologies

Traditionally manure has been spread on land as a useful fertiliser but increasingly concerns over the nitrification of water courses or more seriously the levels of phosphate in soils and water may mean that this option becomes more restricted both at a local and national level. Most of the UK (68%) comes under the NVZ scheme which limits application to 170kg N per ha per year. I could find no legal limits for phosphate but these may be more restrictive if introduced and if they follow the level of scientific concern. Certainly in the USA there is more concern over phosphates than nitrogen and limits in the region of 80kg /ha are imposed in some states. At the same time and ironically, available phosphate is becoming increasingly scarce and valuable.

One of the issues that prompted me to apply for a Nuffield scholarship was; what would the industry do if it found it could not continue to dispose of its manure through the traditional channels? I had been approached by a farmer who had taken manure from one of Noble Foods large laying operations for the last 20 years, who now said he did not want as much as he always taken and maybe not at all for the reasons above. Did this mean that in future it could happen elsewhere where there was a greater concentration of poultry operations or where disposal on the land was already restricted?

Manure disposal direct to land will depend on the quality, which will largely be determined by the moisture content and whether it is mixed with bedding material and the system including whether it is deemed organic or not. In the case of the latter, although a more valuable commodity its disposal must be to organic land which can entail transport over long distances in favour of sources or sites closer to home.

Countries such as Holland and North West Germany have the highest concentrations of intensive livestock in the world. Disposal of manure is already a major issue and farmers must have licences to produce quantities of nitrogen and verify how it will be disposed. They pay between £10 and £20/t for disposal.

One extreme solution already being adopted is the export of semi dried manure to China. Containers arriving at major ports such as Rotterdam, with consumer goods from the far east are returned full of poultry and animal manure to supplement fertilizer in these emerging economies where land is currently plentiful. Whether this has any true environmental credibility or is just exporting the problem, is unknown except that it could be replacing artificial fertilizer derived from fossil fuels.

The disposal of poultry manure has always been a time sensitive operation notwithstanding the limitations imposed by legislation on the times available to spread any material on the land. Private producers may have access to their own land and can accommodate and value the availability of a cheaper source of nitrogen, but when poultry cycles clash with other seasonal farming operations the value of the material has to be weighed up against the cost associated. The problem is worse for organisations or producers without their own access to land. They are beholden to farmers or contractors and see the true value of the product, its transport and removal and the consequences if it cannot be moved.

Traditional deep pit laying units or shallow pit alternative systems usually operate on a 58 week cycle. The flock cycles do not coincide with annual rotations and access to the manure is usually limited to a 2 week turn-round period in which quantities in the region of 40 tonnes per 1000 birds are available at 30% DM.

The material is already a potential problem for the producer, in that it can provide an ideal breeding ground for flies or rodents and is a constant source of ammonia (NH_3) which not only has its own environmental impact but has a detrimental affect on the birds and sometimes the staff and neighbours. Such material is expensive to move long distances, does not always spread easily and does not store well for the reasons above.

In more recent times there has been a move towards belt clean systems for both cage and alternatives. The belts allow some drying of the manure to occur which improves the environment within the poultry house itself, it increases the dry matter of the manure to about 50% making it more efficient to transport and better to store and spread and allows access to the material throughout the flock life. This can be a two edged sword however because conversely it means mucking out has to occur routinely every week, committing time and equipment. Many larger sites have provided a separate manure store into which the belts run to allow a build up of material for more efficient and timely disposal.

A system in practice in Mississippi and North Carolina was a wet flush, in which the shallow pit under the cages were flushed with water from a lagoon on site on a daily basis, with subsequent slurry returned to the lagoon. There was no recovery of the manure except when the lagoon was full but neither was there any issue with ammonia or flies. There was no compromise to the operations or reliance on outside assistance. The system was however not without its problems or critics to the extent that no more such systems will be allowed to be constructed in Mississippi and only under licence in North Carolina. The problem comes back to the issue of management rather than system. A similar system is widely used on pig farms but compromises have been made in the building of the lagoons and there have been too many, and it only takes one, where lagoons have not been large enough to accommodate the quantities involved as well as local rain fall in these hurricane states. The lagoons have overflowed and seriously contaminated local watercourses and supplies.

Having produced the quantities of manure the producer then has to view the product as an asset or a burden and so determine what to do with it. In my study I wanted to address both, find cost effective methods for the handling and disposal and possible uses to increase its value.

5.1 Manure Drying

Given the problems of storing or transporting manure even locally, there are both management and environmental advantages of drying manure.

Firstly however the overall management of the poultry unit must include measures to minimise water retention in the manure, drinker management, ventilation, scraper or belt management and diet will all play a part and need to be right first before investing in any new techniques.

The drying process that can be carried out on belts within the poultry shed itself using air blown through ducts beneath the bird roosting areas, can be enhanced by increasing its temperature through a heat exchanger or air mixer. There are advantages to drying the manure further which require additional equipment and maybe provide more scope for utilisation.

Without belts the only option of reducing moisture content is the constant ventilation of manure in its storage facility, the deep pit.

The longer the manure can stay in the warmer environment of the poultry shed the better, provided it does not compromise the process of removing it or the operation of the unit; a simple solution therefore is to add more belt length than the actual collection length required. This can be done internally or externally to utilise the ventilation within the shed. The alternative is stand alone manure drying off site, usually in batches.

5.1.1 Rose Acre Farms, Ames, Iowa, USA

This large 1.6 million bird layer complex was cooperating with Iowa State University as one of a number of intensive layer sites across the USA in benchmarking the environmental impact that intensive agriculture was having. It was part of a fact based assessment for the National Commission on Industrial Farm Animal Production (NCIFAP) primarily through Perdue University and was supported by the United Egg Packers (UEP).

I was accompanied to the farm to see the monitoring and experiments being undertaken by Dr Hongwei Xin, Head of the Department for Agricultural and Biosystems Engineering at Iowa State University.

The buildings were traditional deep pit layer facilities. The buildings had originally been designed as natural ventilation with a paddle drying system on the manure boards. The system had not worked successfully and had been replaced by a simple system of controlled environment ventilation. This had improved the environment but made little difference to the manure which had to be disposed of at a cost because it was too wet.

They had recently installed auxiliary fans in the pits delivering 36,000m^3/min between the manure rows parallel to the length of the building and had then started to operate the scrapers, 3 times per day. The effect of only depositing a small amount into the pit each time which could be dried meant that manure in the pit now reached 45% DM with a significant reduction in flies and ammonia.

5.1.2 Herbruk's Farms, Grand River, Michigan, USA

I was privileged to be able to visit Herbruck's farms and meet the Vice President Mohamed Mousa.

The company had some of the highest standards of bio-security, hygiene, performance and staff motivation I have seen anywhere. Had it not been for the fact that they had recently installed a new Farmer Automatic multi-tier cage system which was not stocked yet, I would not have been lucky enough to get access.

The company had worked with Farmer Automatic to create their own modification to the belt clean system on this and previous units. The belts immediately under the birds were not ventilated as is conventional but at the end of each bank was a transfer system that conveyed the manure to a complete new series of belts above the cages. Not only did the system allow the manure to be turned for better exposure but it was kept in the shed for a further 7 days before removal, resulting in a dry matter content of 55% without any additional heat or air mixing. (Plate 1)

Standards on the farm were so high that Mohamed's next biggest concern was the amount of dust now being generated outside his fan cowls. This is an inevitable consequence of manure drying.

5.1.3 Dorset Manure Dryers, Varsseveld, Netherlands

The Dorset dryer is based on a series of linked perforated steel plates to form a cycling conveyor. Conveyors which are about 24m in length are mounted in tiers and the whole unit is assembled along side the poultry house. Material is delivered and spread evenly on the top tier which is constantly moving and cascades down onto lower tiers over a period of about 5 days before removal.

The drying process is by the passage of air through the perforated plates. The drying capacity is determined by source of air.

Using the exhaust fans from the poultry shed avoids the need to find an additional heating source but its capacity is limited by the drying capability of the exhaust air. It is likely, especially in cooler conditions that exhaust air; delivered only to maintain minimum ventilation for the birds or minimal temperature control, will already be high in relative humidity and unable to absorb much more moisture.

The other major problem is that most conventional ventilation fans are designed to move large volumes of air with little or no back pressure. The ducting and restricting of air flow through the system will lead to fan inefficiencies, increasing power consumption, reducing equipment life and compromising ventilation rates. It also lends itself better to facilities with tunnel ventilation where ventilation equipment is concentrated. It would therefore be more beneficial to install a Dorset dryer in its own location with a completely separate ventilation and heat source.

The dryer claims to be able to dry poultry manure from 35% DM to 85%DM by using a ventilation rate of only $2m^3$/bird.

The air can be delivered though a heat exchanger which enables it to be lower in RH and utilises heat energy already generated but there is one problem with belt or plate type dryers. The Dorset dryer is designed to operate at one speed to cope with a regular supply of fresh manure at the top. If material quality or weather conditions vary within the drying process and the unit is linked to a regular belt clean operation, it means the finished product will vary in terms of dry matter.

Dorset has now started to concentrate on the drying of the residue from biogas plants. They have their own drum separator and use the heat from the plant to dry the solid material from 10%to 90% DM but for a total energy consumption of 300 MJ/m^3. If the objective is to reduce slurry to a solid for easier disposal this may be inevitable energy consumption.

Typical cost of a plate conveyor dryer suitable for an 80,000 bird unit is about €120,000.

5.1.4 Agro Supply, Meerheide, Holland

An alternative manure dryer was shown to me by Stefan Baselmans, Agro Supply, that was designed more for the direct drying of layer manure.

While still in development it consisted of a revolving drum approximately 12 m in length and 3m in diameter.

The unit was completely separate from the poultry unit except that it used air through an Agro Supply heat exchanger that was connected to the layer unit. The warm and relatively dry air was passed into and through the drum through an internal perforated duct. As the drum rotated the material constantly fell over the internal duct and was always mixed. The drum could take a batch of 12 tonnes of fresh manure at a time and the whole unit was mounted on load cells so that the removal of moisture by weight could be monitored. (Plate 2) The dryer could reduce moisture from 65% to 25% over 5 days or in other words extract 5 tonnes of water.

The unit's limitation was the fact that as a batch drier it could not cope with regular supplies of fresh manure and was limited to 12 tonnes but this is the quantity derived from a 16,000 bird unit in one week. In its favour however was the fact that the final dry matter could be determined by the length of time the material was in the drum and accurately predicted which enabled the producer to supply a consistent product to his customer. In the example the farmer was supplying a local power generating plant that required a maximum of 25% moisture content.

Material from both driers was friable with small particle size and low in odour. If the drying process only allowed DM to reach 65%, the material would be suitable for pelleting. The heat generated under pressure of the pelleting process would reduce the final pellet to about 80% DM and the pellets are then much more user friendly for transport, spreading and / or burning.

5.1.5 Summary

- Manure drying is already widely used to some degree or other.
- Manure drying can add value to poultry manure where there is a market.
- The drying process reduces moisture and odours making the product easier to store and transport.
- When it can be exported as a result of improved value or ease of handling, it can alleviate soil and water pollution in the local area.
- Drying does not eliminate the final impact as the total nutrient output will be very much the same, however in terms of mitigating the need for artificial fertilizer where it is applied, it has a contribution.
- It has definite environmental advantages, provided the delivery systems utilises energy already in the system.
- The value of the final product will determine to what extent the material has to be dried.
- There are options for both continuous and batch drying and the ability to control drying capacity which may enable producers to dispose or utilise their finished product most cost effectively.

5.2 Composting

Composting is the aerobic breakdown of organic material by naturally occurring microorganisms. If done correctly and for the right reasons it can deliver a real environmental benefit by removing excess nutrients from land limited operations.

The composting process reduces the moisture content of the original material making it more economical to transport. It also renders the material into a more friable texture making it easier to handle in different applications.It has two limitations however. The product will still deliver the same soil nutrients as the original manure. It can therefore only solve the problem of disposal at the local level. The second factor is scale. In all but one facility I visited, composting could not cope with all the manure produced by the enterprise.

Composting can create its own environmental issues as well.

Poultry manure especially pure material requires the addition of high carbon material such as sawdust or straw, where this has to be imported there is a potential net environmental cost.

Extensive outdoor windrowing systems require land, and drainage catchment to contain run off. They are relatively inefficient taking up to 3 months to convert to a suitable product and with commitment of time and energy in turning and monitoring. They therefore can present additional problems with storage on enterprises where manure is produced regularly.

More sophisticated operations using mechanical turners or drums all under cover are more efficient and could create friable compost within 2 weeks but at much higher capital and operational cost that even some proponents say are unviable.

In either case poor management can create problems of anaerobic decomposition, which will lead to odour complaints and a potentially environmentally harmful product.

The real advantage of composting is in the disposal of more contentious materials. As the composting process raises the temperature of the material to above 70° C so the product is in effect sterilised. Therefore as an alternative method of disposal of carcases or hatchery waste there are definite advantages if allowed to do so, over the burning of fossil fuels in incinerators for example.

Waste handling regulations in the UK mean that planning permission is likely to be required even for on farm operations, in order to develop a composting facility where either the raw materials or the finished product are not entirely derived or used on the same farm.

Legislation on the disposal of animal waste and animal by - products would prevent the incorporation of any of the contentious material I refer to, at least within the UK.

Less contentious materials which would otherwise go to landfill can be incorporated under licence and do provide an environmentally sound means of disposal with added value for which poultry manure may assist as a means to an end.

5.2.1 Hyline Grandparent Farm, Dallas Center, Des Moins, Iowa, USA

The Hyline grandparent farm at Dallas Center, Des Moins, Iowa has 66,500 grandparent birds housed in deep pit buildings on a high bio-security site.

Mortality from these birds amounts to approximately 3,000 carcases per year.

The hatchery nearby has a capacity to produce 6 million layer chicks per year which obviously means there are 6 million reject male chicks to dispose of plus the disposal of reject / surplus eggs.

Bearing in mind that rendering in the state of Iowa was being severely restricted and indeed within other US states such as Michigan, the last rendering plant was due to shut down that same year, there was little alternative for the disposal of spent hens on a regular basis. Some sites had invested in incinerators but most hatchery waste and dead stock went to landfill. There is no legislation on the inclusion of animal by - products in compost or their burial. Iowa has the largest population of pigs and poultry per ha of any state in the US and so has a major problem with the disposal of manure. Phosphate and nitrogen levels in soil and water are a major concern. Composting was therefore a realistic solution.

Here was an example of enthusiasm, dedication, and innovation because Hyline had appointed and tasked an individual named Dave Welch to find solutions for the disposal of these materials. He had experimented with combining, separating and composting the various components using fairly rudimentary equipment and had succeeded in disposing of it all.

As part of the process, liquid eggs from the hatchery and the farm were melanged and the shell separated. The liquid was either dispatched as a concentrate to a local mink farm during the season or was mixed with water at 50% to be applied as silage aftermath treatment. Small quantities were used in concentrated form as a localised spray around garden shrubs and fruit trees as a deterrent against deer grazing, a common problem in the rural areas of Iowa. It is a unique solution that highlights what is possible when a dedicated effort is applied without constraint.

Hatchery waste and mortality were collected at a central bio-secure point on the complex and macerated. It was then blended with the manure and bulk material in the ratio by weight of:

45% hatchery waste and spent hens

30% manure

25% bulk material

The bulk material could be maize, sorghum or soya haulm, wheat straw and even paper.

The mixture was blended in a standard feed mixer wagon before being heaped in rows in dedicated poly tunnels for the composting process. Each poly tunnel held 6 weeks of material with a daily input in rotation. Temperatures reached 70˚C which sterilised the material and within 6 weeks with regular turning, rendered the whole batch to a friable, virtually odourless and biologically inert material for sale through retail outlets. Disposal of material through a renderer was 4.5 cents /lb but this solution only cost 1cent/lb, including labour fuel and equipment. (Plate 3)

Animal By -products and Waste Handling legislation would prevent an operation like this in the UK despite its environmental credentials. Compare this for example to a typical farm incinerator that can burn 8 litres of fossil fuel per hour to combust 50- 100kg of material over an 8 hour burning cycle.

There is no doubt that the operation was highly reliant on the individual. It worked because of the relatively small volumes involved and the value placed on the bio-security requirements for such a sensitive operation but did it really solve the problem of disposal of manure and the nitrification of water courses or just export it slightly further afield? It certainly solved the problem as far as Hyline were concerned, particularly the disposal of their most contentious material.

5.2.2 Green Meadow Farms, Elsie, Michigan, USA

I visited a large dairy unit in Michigan on recommendation to see manure handling facilities for the 3,500 dairy cow unit

All stock was zero grazed with maize and alfalfa from the 2,650 ha estate.

All the cows were bedded on sand in their cubicles to reduce bacterial build up and flies but this created a real problem with the slurry which retained a lot of the sand and which had to be recovered by washing and settling. They could recover about 85% but the quantities of water used and the sophisticated pumping system made them very reliable on an electricity supply and a good mechanic! The purpose for the visit was to see a new biogas plant installation for the generation of their own electricity, but they had already tried composting.

Once the sand had been separated, the slurry was very liquid probably only 2-3% solids. It was pressed mechanically to extract the water and finished up at about 55% DM, not dissimilar to poultry manure. The water was recycled to wash the passageways and then back into lagoons.

A proportion of the solids, only 25%, were mixed in a 50:50 ratio with bulking material, in the form of waste silage and maize chaff and then windrowed in a paddock with regular turning for 3 months.

The composting process had worked very well and they had even used it to dispose of their fallen stock, a whole cow could disappear within 3 months. There were no flies, no smell and they could claim to be low carbon. The system however highlighted the limitations of composting in this way. Firstly their extensive windrow system could not cope with the volumes they required, even at 25%. It required enormous amounts of time to turn the windrows regularly and it took up a lot of space. (Plate 4)

The area required, that I would estimate to be about 2ha, was too large to justify the provision of a solid floor and proper catchments. It failed to meet regional legislation requirements as it was unable to contain run off of rain water. Its environmental impact was probably greater than its contribution.

It was for this reason that the farm was working with Michigan state university to develop a biogas plant.

5.2.3 Michigan State University Farm, Lansing, Michigan, USA

The state university farm composting operation, managed by Dana Kirk was a more sophisticated facility in which material was stored in concrete clamps all under cover and was turned by automatic aerators running on rails above the clamps. (Plate 5)

The facility only had to deal with the manure and carcases from the campus farms although in total volume terms, it was probably the equivalent of a single large livestock enterprise and did include a relatively high percentage of manure and bedding from the equine centre. It had also recently started to handle food waste from the campus but had come up against the same problems. It could not cope with the volume and was handling only 75% of the livestock material and again while the process handled the material and dealt with the fallen stock adequately and produced an acceptable finished product it was not really a viable commercial operation. It was under pressure for odour emissions and it had not solved how to dispose of the material it had created.

In contrast to the outdoor windrowing system, the material became too dry and water had to be added and each batch had to be inoculated to start the process.

5.2.4 Summary

- Composting can add value to poultry manure where there is a market.
- Poultry manure can add value to compost that is primarily designed for the disposal of more contentious waste.
- The composting process reduces moisture and odours making the product easier to store and transport.
- When it can be exported as a result of improved value or ease of handling it can alleviate soil and water pollution in the local area.
- Depending on the system the process can cope with manure plus other materials of small to medium size units but is limited as scale of production facilities increase.
- The process renders potentially bio-hazardous products inert, without resorting to incineration or chemical treatment.
- Composting does not eliminate the final impact as the total nutrient output will be very much the same, however in terms of mitigating the need for artificial fertilizer where it is applied, it has a contribution.
- Establishing a composting facility may create additional environmental impacts of its own.

5.3 Biogas

I had expected to find more solutions for the use of poultry manure in biogas than I did.

The USA, before the recession unlike Europe was not driven by energy costs and had no environmental legislation to encourage alternative energy sources. The bio-ethanol from cereals movement was certainly underway but there were no financial incentives for on farm production of electricity to feed back into the national grid. Power companies only needed to pay their current production cost rate for any electricity put back into the system, regardless of the production method. One could argue that this did not encourage development of more efficient methods or techniques but it did mean that their technology was based on science and not distorted by the need to meet a legislative or artificial financial objective. There was therefore great scepticism that biogas plants using poultry manure would become viable. The development of biogas plants in the USA has also largely been driven by the requirements of the dairy and intensive pig sectors, who have higher volumes of liquid slurry and are seen as a greater environmental burden, while poultry manure can be still be applied direct to the land. In Europe biogas is not seen as a means of waste disposal but only for profitable energy generation.

I visited the Agritechnica Exhibition in Hanover where the world's best technology in terms of biogas was on display. In meetings with technicians from various organizations, I found little enthusiasm or recommendation for poultry manure as a raw material for their plants. I never managed to find a site either in USA or Europe where they were using it.

Production of methane in a biogas plant is a result of a series of bacterial breakdowns of the organic matter in livestock manures from carbohydrates to sugars and amino acids and then acetic acid and finally methane. Straight poultry manure does not contain enough carbohydrate to initiate the process and so on its own does not work well in biogas operations. It also contains too much silt, especially layer manure with the limestone inclusion in the diet and is too high in nitrates and uric acid. There are experiments and plants in operation that claim to utilise up to 50 % poultry manure but this is largely from litter based systems.

There are 3 main methods of methane production and several systems which adopt one of the following

- Cytophyllic: ambient temperature
- Mesophyllic: ambient temperature in warmer climates 38˚ or addition of some heat.
- Thermophyllic: heat added 55˚

While the latter is the most efficient for methane production due the addition of heat; every 10˚ increase in reaction temperature, doubles methane production. The residue is made sterile and bio-secure but in terms of net energy contribution and therefore the net impact to the environment one has to question its value.

Covered Lagoons with a cytophyllic system could be incorporated on the wet flush systems where they exist. They would prevent the danger of overflowing because the lagoons are covered but are relatively inefficient and the areas that need to be covered are quite large and therefore expensive. They will however cope with requirements of regular additions and flushings as dictated by the house system.

Batch Digesters can be any of the systems but are limited to taking set volumes at a time which poses problems for regular disposals of manure. Peaks and troughs in the supply of manure depending on the production system mean that storage facilities need to be incorporated into the project.

High Solid Anaerobic Digesters (HSADs) 10% solids as oppose to 3% which use pit sludge from another plant and are thermophyillic are likely to be more successful and better able to cope with the higher protein levels in poultry manure but need additional heat .

One of the problems is that if it cannot be justified on its own on, a poultry unit requires a joint operation with say a dairy or pig unit. This means manure has to be transported one way or the other. The relatively high moisture content of both poultry and other manures in their raw state makes transport expensive and yet there is little point in trying to dry it when the biogas process only requires the re-addition of water. In the high livestock concentration areas of Germany and Holland they already produce more than twice their requirement of manure in terms of phosphate so the material already has to be exported.

I believe there could be more scope in community based projects. Such community developments are being initiated in Europe especially Austria but I would suggest that the throughput for each waste contributor is low and therefore would not solve the disposal of manure from anything more than a small production unit. While addressing a local environmental issue, projects like this especially in Europe are often heavily subsidised and could not be justified otherwise.

While I was travelling in Europe and meeting academics as well as practitioners, I learnt of biogas plants, not necessarily utilising poultry manure but nevertheless established with state or regional subsidy and which operated profitably but which actually consumed more energy than they produced!

Successful biogas plants may provide a financial value to the utilisation of some poultry manure as there is still a manurial value after one has derived some energy from it but they should not be viewed as a manure disposal option. The sludge at the end has reduced little in volume or content from the original manure.

5.3.1 Envitec, Agritechnica, Hanover, Germany

Although not able to visit a bio-gas plant using poultry manure I met Bernhard Meyer zu Rheda and Roger Smith at their stand in Agritechnica who provided the following information and subsequently Dr Brockman at Vechta University who provided impartial and more general information.

A typical 500kW plant will require 7000 tonnes of poultry manure per year at 35% DM, to which has to be added 30,000 tonnes of water. This quantity of manure is the likely output from about 150,000 layers.

Envitec would not recommend any more than 30% of the total material to be poultry manure and would require the addition of other carbohydrate based material or other farm/processing waste such as offal. The demand for alternative materials, following a peak in the commissioning of biogas plants in Germany in 2006 has increased the cost of operating all bio-gas plants.

A 500kW plant will produce under the German renewable energy scheme about £400,000 worth of electricity over a 20 year period or £20,000 per year. Depending on the source and the materials used German farmers can sell electricity generated from Biogas plants back to the grid at €18 cents /kW. The current cost of electricity from the national power supply companies is about €15cents/kW.

They confirmed that the residue had lost little in terms of its original manurial value but was more consistent and produced fewer odours than the original. However in terms of the NPK mix the residue, which is about 90 % solids, contains about 90% of the Nitrogen in the solid component but only about 75% of the phosphate. The solids following separation can be transported away but the liquid needs to be spread locally. The area of land to dispose of 25% of the phosphate is greater than the area required to dispose of 10% of the nitrogen, so disposal of the liquid component is still a problem. Applying the residue to phosphate dependant crops such as maize allows some up take but the phosphate remains in the food chain, being fed back to livestock. With the importation of additional phosphate from soya and protein crops supplementing the quantity in the manure, it means that phosphate disposal is becoming increasingly difficult. Separation itself is an expensive operation costing about €8/tonne bearing in mind the quantities involved (37,000tonnes).

5.3.2 Summary

- Biogas does not work well with poultry manure, especially as a pure material.
- The motivation for biogas installation appears to have very little to do with the derivation of energy or an alternative means of disposal of livestock waste but more to meet a political demand for which governments are prepared to subsidise to make them financially worthwhile.
- Using poultry manure for biogas does not eliminate the final impact as the total nutrient output from the residue will be very much the same.
- For the quantities involved it does allow some energy to be derived while retaining a manurial value to replace artificial fertiliser.
- The fact that the process requires cooperation with other material sources and substantial quantities of water makes transport and handling more difficult that the original manure.
- Biogas facilities are highly capitally intensive, despite the potential for subsidy.
- Biogas does allow energy to be stored to suit demand.
- Establishing a biogas facility may create additional environmental impacts of its own.

5.4 Biofuel

A new technology that is being developed in Pennsylvania USA is the use of offal from all livestock processing facilities to produce diesel replacement fuel. This would provide an alternative to the current US practice of sending all livestock waste to landfill and as an alternative to the disposal by incineration or composting. Location of such plants is likely to raise local objection but must be near the processing plants with suitable collection methods.

5.5 Biomass

This is where I saw the most potential although the technology is relatively new but developing fast.

There are already plants such as the Fibrowatt power stations utilising poultry litter from sites within an economical transport range. These commercial facilities use either fluidised beds or travelling grate boiler designs to power steam turbines for electricity. Between the four currently in operation in the UK they burn about 400,000tonnes of poultry manure per year. The material however has to be relatively dry (75% DM) and contain sufficient combustible material. Pure layer manure, especially with the higher calcium content produces too much ash. Broiler farmers able to secure contracts for supply which can be for up to 10-15 year periods, can be sure of financial security and assurance of disposal.

Where I think there is most potential is the use of biomass to generate energy at the local level. There are advantages of reduced transport, better bio-security, more direct use of the energy and development of combined systems for the drying, combusting, and handling of the material.

Unfortunately, burning of poultry manure and litter is not possible in the majority of solid fuel biomass burners designed to combust alternative fuels such as wood chip, straw and miscanthus. Combustion is difficult and temperatures are never high enough to burn off the noxious gases produced, particularly nitrous oxide and dioxins. Small scale gasification plants are available which are capable of operating from 100kg to 25 tonnes of material per day. They produce very few, if not zero emissions and if sited correctly can deliver various energy options. Direct and indirect heat through water can be delivered for operations such as brooding, electrical or mechanical energy via Sterling engines and then there is the potential for cooperation for off site use.

It is interesting to note that with increasing energy costs the popularity of biomass burners in Scandinavia, mainly relying on wood chip, which was a plentiful resource, has increased dramatically in recent years, to the extent that the value of wood chip now competes with oil and gas in calorific terms. This is either a potential new revenue stream or a justification for poultry growers to be responsible and in control of their own fuel resource. It is also worth reporting that with the development of the latest generation of gasification biomass burners, especially when installed as part of a Combined Heat and Power Plant (CHP) the value of poultry manure as a fuel is potentially greater than the nitrogen value.

The complete combustion of poultry manure in a gasification plant involves the conversion of high carbon material into hydrogen and carbon monoxide at high temperature. This combined gas, known as syngas is further burnt to produce heat energy and to render the final flue gases as harmless. It is therefore environmentally more sustainable than conventional fossil fuel heat generation; although it is likely that pure layer manure will need to be blended with some other material for best efficiency.

The nitrogen element in the manure is burnt off but phosphate is retained in the ash. The burning process ensures a better purity and quality, with the opportunity to recover it far easier than would be possible from raw manure. At current values for phosphate of £500/tonne this could make the ash a valuable by product.

The only harmful by product from the process is dust from the exhaust flu which may contain dioxin. Provided suitable dust scrubbers are installed this is capable of being collected.

A biomass burner can be combined with an electrical generator but will still generate excess heat which can be used on site.

Direct heating using hot air is probably the simplest but requires the plant to be located near the heat sink and on a typical poultry farm with several sheds distribution will be difficult without multiple installations. Heating water which can be distributed is more feasible although temperatures and efficiencies will deteriorate both in distribution and utilisation.To utilise hot water as a means of heating livestock buildings as oppose to kerosene or propane has the advantage of delivering dry heat. Every litre of propane burnt creates 0.6 litres of water vapour.

Producers who can generate heat from their own biomass can sell or transfer the heat to other enterprises, or even neighbours, if they have no requirement of their own. If the technology allows the introduction of biomass burners into other commercial or domestic situations, it could create demand for alternative fuel sources and so create a new market for poultry manure provided it can be made into an acceptable form. This may involve facilities for processing and storage, such as pelletising but in themselves may be part of a positive environmental contribution.

5.5.1 Big Dutchman, Vechta, Germany

In discussions with Armin Schwarz of Big Dutchman we calculated the potential energy value for layer manure as a replacement for propane in the rearing of layer pullets.

1 kg of poultry manure solids has an approximate calorific value 7MJ

1 litre of propane has a calorific value of 25.5 MJ per litre

The value of wood chips is approximately €200 per tonne for a calorific value of 14 MJ /kg and so in calorific terms poultry manure should attract about half that value.= €100/tonne

Although biomass burners do not need the material to be dried below 25% DM, which is achievable through several of the manure drying techniques above, there are benefits but also costs associated with these processes which range from €10-€20 per tonne. The value of the manure has to be adjusted to a fresh weight value of €75/tonne at 25% DM

Propane at the time of the discussion was about €30 cents per litre

To brood 100,000 layer pullets requires about 30,000 litres of propane at a total cost of €9000

The amount of energy consumed = 765000MJ

In order to replace this by using poultry manure it would require 136 tonnes of 25% DM manure.

This would be the output from about 10,000 layers over a year.

Calculated in terms of true market value the poultry manure at €75/tonne in a biomass burner does not compete against propane but the value only has to drop to €66/tonne or propane to increase to € 35cents/litre to equate and in comparison to realistic disposal costs for manure in Germany and Holland at €10 - €20 per tonne it makes the option look attractive.

5.5.1.1 Pelleting

Whether the biomass burner uses material from its own site or from another there is the danger of bio-security. Drying to 25% and then pelletizing will in effect sterilize the manure. The pressures involved in the pelletizing process will raise the temperature of the material temporarily above 70˚ and will further reduce moisture to 10% to inhibit bacterial and fungal growth.

5.5.2 Dept of Bio-systems and Agricultural Engineering, Michigan State University, Lansing, Michigan, USA

The US Department of Energy has set aside $125m to investigate alternative fuel sources and BP whose acronym now stands for "Beyond Petroleum" have sponsored the project by a further $15m. The use of poultry manure and litter as a direct fuel source is just one avenue being investigated.

Professor Ajit Srivastava, and his team are currently working on a version of a Controlled Volax Close Couple Compressor burner capable of utilising turkey manure which contains litter and sawdust in a 50:50 ratio. The burner will generate 0.5 m BTUs but remains suitable for small farm installation. The initial aim is to create a suitable burner for greenhouse production and is therefore designed to provide heat from hot water, which it does with about 80% efficiency. To produce electricity in a CHP reduces efficiency to about 40% in terms of Kw. (Plate 6)

Temperatures within the burner reach 850˚ C which is sufficient to burn off noxious gases and the material is reduced to an inert ash which is only 0.3% by volume of the original material.

This plant is a continuous process.

5.5.3 North Carolina State University, Raleigh, N Carolina, USA

As part of the same project being undertaken in Michigan, the team here has developed a batch burner capable of accepting 40-50 kg per batch but with the expectation that units will be developed to accept batches of 500kg. Each batch takes 12 hrs and is self perpetuating if followed immediately by another but otherwise the process does require the ignition from propane. The technology is very similar to that currently employed in carcase disposal incinerators and indeed part of the criteria in this project was to dispose of fallen poultry stock. The necessary temperatures of 850˚ are reached but ash deposits are higher at 12 % by weight.

5.5.4 2G Energietechnik, Agritechnica, Hanover, Germany

Despite the developments and finance available in the USA, there was a general consensus that technology in Europe, especially Germany was the most advanced, in terms of biomass burning.

The only manufacturer however that I could find whose biomass burners claimed to be able to handle poultry manure was 2G. They make a range of burners from 40 KW to 300KW

The burner will accommodate a range of fuels. Each fuel type is tested and the burn profile is programmed into the controls. It is capable of storing the burn profile for up to 10 different fuel types allowing one to alter fuel types according to availability or cost.

Despite claiming to be able to handle layer manure it is recommended to blend the material with some other fuel type more rich in carbon. All fuel types should be at least 75% DM.

Their calculations estimate that 80kg of manure will generate the minimum 40kW of power and that 20 tonnes of dry manure will produce the same energy as 10,000 litres of heating oil. This means poultry manure has a value of €200 per tone, even in its fresh semi dried state. This value is close to the value of wood chips and so allows it to compete on the open market with other biomass fuels.

The process is a continuous two stage gasification with the opportunity to draw off the syngas after the first stage to power an independent sterling engine generator. The syngas can be and usually is left for its secondary burning in side the plant to raise temperatures for steam generation.

Water heated by the plant can be drawn off at 75˚- 80˚ for distribution and use and the exhaust gases are discharged at about 140˚-160˚. Currently no use has been made of this exhaust heat but it could be used in heat exchangers or heat pumps and maybe available to assist in the drying of the raw manure fuel.

Emissions of CO_2 and other gases are negligible and the ash left is about 10% by volume. The higher the proportion of manure compared to more combustible material the higher the ash content to a maximum of 20% by volume for pure layer manure. Broiler litter which already contains a proportion of shavings or straw can be burnt without blending and with less ash residue.

A typical 40 kW burner occupies a space of no more than a large domestic upright freezer and can be purchased for about €18, 000.

5.5.5 Summary

- Biomass burning can allow poultry farmers to take control of their own energy supplies.
- It provides a genuine alternative to the disposal of manure to the land.
- The technology is already capable of utilising the raw material without the need for extra processes and is still improving rapidly.
- The process can supply heat and power at a local level.
- The gasification process allows complete combustion with no emissions.
- The concept need not be confined to farm or production sites and can therefore create a market for fuel from the manure.
- The residue, with the exception of the flue dust, is a valuable by product rich in purified minerals.
- The technology is not as capitally intensive as biogas, nor as time consuming as composting.
- Although the process currently requires a blend of poultry manure and other materials, these are relatively easy to source handle and store with minimal environmental impact.
- Concerns over bio-security can be overcome.

6.0 Alternative Energies

Deriving energy from alternative sources is now the focus of governments, businesses and individuals.

We all know that we should be trying to derive our energy from non fossil fuel sources but the energy must be reliable and cost effective. The technology is largely proven in the laboratory and may be even domestic level but is less convincing at commercial levels.

We have already looked at generating heat and electricity from biogas and biomass as a means of improving the value of poultry manure and putting poultry farmers in charge of their own energy supplies but what about contributing towards the energy requirement from natural renewable sources, wind, solar, geothermal, ground source, hydro and others.

I could not investigate all these especially in any detail so I concentrated on those most likely or already adopted.

The problems with all natural renewables is the fact that it is highly dependant on geographical location, globally, nationally and even locally and is also often subject to fluctuations in natural patterns, diurnal and annual cycles and weather. This means that it is often not so much about the ability to generate power but how to store it and use to make it reliable.

The proliferation of wind farms across the UK and Europe now make a significant contribution towards national electricity supplies, Germany is already up to about 15% but the nation still needs to have the back up of conventional power stations to meet peak demands or cover low output from the wind turbines.

6.1 Wind power

Already a common feature on small mobile poultry units and increasingly observed on domestic and commercial properties.

I did not investigate wind power in any detail within my study because I felt that poultry farmers had no special facilities that made the technology more attractive or more suitable to their requirements, than any other business. Wind generation can certainly make a contribution towards reducing one's environmental impact and is open to everyone depending on their location, needs and ambitions, but it must be justified on its own merits. In my experience there were some limitations.

Firstly and this is probably self evident the technology is relatively expensive for the contribution it makes, hence there are few examples of anything more than small wind turbines on mobile units. Payback periods can be into 10s of years, especially when one is looking for security of supply. You have to remain connected to the grid to ensure supply at times of high load or low wind.

Small turbines supplying DC current for storage in batteries do allow power to be delivered to remote locations where generators might otherwise be used but in my experience there is often no net environmental benefit. Fluctuations in demand and supply meant that batteries regularly had to be charged at the mains even when run in combination with photo-voltaic cells. Dull, still foggy days in the winter provided no power generation when demand in the shed remained constant if not higher.

Technological advances in battery storage capacity, driven by the increasing demands for electrical power not least for transport purposes and improvements in the efficiency of turbines will mean that this form of alternative generation will become more attractive.

The positioning of turbines is critical. The difference in generating capacity between two similar turbines on the same day where one was positioned closer to a bank, hillside tree line or other building was probably as much as 30% without being visibly obvious.

6.2 Solar

One asset that most poultry farmers are blessed with whatever system is relatively large roof spaces.

The idea that this roof space can help generate energy, is attractive and worth exploiting especially when the fixing of solar panels, whether for electricity generation or water heating, also provides additional insulation.

Solar power must be the ultimate renewable energy source, after all the sun produces about 8500 times the whole world's energy requirement each year. It is silent, unobtrusive and even taking account of latitudes and weather, more reliable than wind, and more applicable than hydro and geothermal both of which are determined by geographical location or access to land.

6.2.1 Solar thermal

Solar heating of water has been in use for decades but the technology has progressed substantially in the last couple of years. Most installations now use a series if evacuated tubes, coated in a material to prevent radiation back out of the tubes. Each tube houses an absorber. Different manufacturers will use different materials for their absorber, but they will generally either be copper or glass. A refrigerant liquid transfers the heat from the absorber to water via a heat exchanger for use or storage. Installations are usually modular and can be added to as required, making them easy to install on a large roof. Different manufacturers claim that their equipment can be mounted vertically or horizontally but of course position relative to the predominant rays of the sun will affect efficiency.

A typical solar water thermal installation will generate between 500 and 800 kW per m^2 per year but heating water is quite energy intensive and this equates to only enough energy for about 40% of a domestic heating and hot water requirement. This size installation could cost in the region £2000 or an installation price of £2.50 - £3.00 per Kw.

In temperate climates the efficiency of solar water heaters is limited. The quality of materials within an ideal installation can be assembled to render the system efficient even in cloudy and low sunlight areas but the cost becomes prohibitive. I could find no commercial or semi commercial installations in Europe but when discussing the merits of solar thermal with farmers in Germany who had subsequently installed photovoltaic they claimed that payback was a minimum of 10 years.

As regards the potential for poultry producers and siting on agricultural buildings there are two other considerations which restrict their potential.

The quantities of dust likely to be deposited on the uppermost surfaces, especially if the dust contains oils and grease commonly found in poultry feed, means that solar penetration could be inhibited in time. While this is the same for all solar energy applications, the more fragile nature of glass tubes makes cleaning large areas a more delicate operation and the tubes are prone to break. The tubes can however usually be replaced individually.

The second factor is that the provision of hot water is best done close to the point of use. Poultry houses have limited requirement for the provision of hot water and so without installing further facilities to utilize the water in some way or being able to transfer the hot water to a point of use it is unlikely to be justifiable.

I believe however that there is scope to utilize hot water generated in this way either for direct heating especially under floor heating, to preheat air through inlets and into heat exchangers. These will only become reality when current energy costs justify the high capital cost and where there are opportunities for new build. Installation of under floor heating able to withstand the rigours of commercial poultry farming is likely to cost in the region of £45 - £50/m², with a typical broiler shed in the region of 1800m² that requires an investment of £81,000.

Poultry houses that generate their own heat for the majority of the time would find better efficiency with heat pumps using the difference between internal and ambient air temperatures.

6.2.1.1 Summary

- Solar thermal can utilize available roof space.
- It is usually modular for easy installation and addition.
- The panels are subject to loss of efficiency from dust.
- The tubes are more fragile and inflexible than photovoltaic panels for large commercial installations.
- All solar energy generation is subject to loss of efficiency from latitude in UK.
- The benefits are only truly derived when a use for the hot water is nearby.

6.2.2 Photovoltaic

Photo voltaic panels generate electricity by the energizing of metallic plates by sunlight causing electrons to be emitted. The panels are usually mounted within glass or poly carbonate and can be very thin and therefore easy to install, just like a roof sheet. As with solar thermal panels, they come modular to allow build up of larger areas connected together.

They are best mounted on south facing angles of 25-30˚ in northern temperate latitudes to be most effective but will be more effective than the equivalent solar thermal panels, if placed in less ideal positions. Unfortunately most poultry buildings do not have roof pitches of such angles so while they will provide some insulation if laid parallel and close to the roof sheets, their full potential is already compromised by doing so. There are sophisticated mounting systems to achieve the ideal angle, including computer controlled adjustment that will always maximize exposure to the most direct sunlight. These are seldom worth it for the benefits derived and would certainly be cost prohibitive on a poultry shed.

As with solar thermal panels, dust and debris can affect performance but these units are easier and more robust to clean. Their popularity within the area of Germany I visited has warranted the establishment of a specialized cleaning service.

Many photovoltaic panels are mounted in aluminium frames. The relatively high levels of ammonia around livestock buildings lead to corrosion and some photovoltaic cells themselves are prone to deterioration from ammonia.

My visit to the Agritecnica Exhibition in Hanover exposed me to a range of photovoltaic possibilities for the generation of electricity. I found out that there were no substantiated claims that one was better than the other and that the proliferation of installations across Germany, was more to do with the financial returns as a result of generous government subsidies and less to do with energy conservation or a real desire on behalf of the producer to generate electricity from renewable resources.

Photo voltaic cells are expensive in themselves, about £3800/ kW, they are obviously less efficient in more northern latitudes and current technology claims a 1% decline in efficiency year on year although most systems are expected to last a minimum of 20 years. As you will see from the example, at current returns they need to perform for at least this length of time to be at all viable. Without investigating too much into the manufacturing process, I gather that their manufacture involves using cadmium and other heavy metals and the process is not without its own environmental impact, so much so that without a significant contribution towards energy generation their net environmental value is questionable.

6.2.2.1 Free range layer farm in Germany visited through Big Dutchman, Vechta, Germany

A 20,000 bird free range unit on which he had installed 240m² of photo voltaic panels in 2004.In terms of the roof space available this was only one third of one side. He would not have been able to use the other side anyway as it was not south facing but there were other reasons why he had not exploited the whole area. (Plate 7) The 240m² generated 30kW/hr at peak output, which equated to 1.25kW /10m² this is in line with manufacturers claims which quote an average 1 kW /10m².

The installation had cost him €118,000 for which he had secured a 30% grant. This grant was available only to installations of 30kW or below. This was one reason why he had restricted the size of his installation. Costs of the panels at the time of his installation were about €4800/kW but now are more likely €3800/kW.

There were two further reasons why he had not utilized as much roof space as was available

To completely cover his one side of the roof would make access for cleaning very difficult. In so doing it would mitigate any benefit there may be of the panels providing any substantial insulation.

He was very suspicious that the power supply company to whom he sold his electricity had imposed a restriction on his supply capacity through their transformer. The supply company while under a legislative obligation to buy back electricity from installations such as this were being forced to purchase electricity far more expensively than they could produce themselves or even than they could sell. It was therefore not in their interest to have to maximize their uptake from such installations.

The current policy by the German government to encourage renewable energy generation on farm was an enhanced payment for electricity put back into the grid starting at €57cents per kW and then declining on a sliding scale by 5% per year so that he was being paid €49cents at the time. Electricity supplied by the national power providers was €15 cents per kW.

In the 3.5 years since installation he had generated 100,000 kW of electricity in total, which was slightly over one full crop power utilization. He purchased all his power from the national supplier and sold all he generated, rather than producing for himself which at these figures made economic sense.

The financial return therefore was

100,000 kW over 3.5 years = 28500kW per year

Average value of electricity sold back into the grid = €53cents

Cost of actual electricity purchased = €15cents

Margin /kW= €38 cents

Margin per year = € 10830

Original capital cost of installation = €118,000 (not counting any grant assistance)

Return on capital = 9%

The following points need to be considered in the German model

As more electricity is produced from renewable resources in line with national and European targets, it will make up a bigger proportion of the total supply and the cost of electricity in the national grid will increase.

There will be increases in electricity prices generated from traditional fuels, gas, oil and nuclear.

The scale of prices paid for electricity from renewable sources is reducing by 5% year on year. This was a deliberate policy to reflect and control exploitation of the scheme as cost of technology improved.

If one was to transpose this to the UK situation where encouragement for renewable energy generation is paid for through a scheme of ROCs (Renewable Obligation Certificates) and LECs (Levy Exemption Certificates)

ROCs are issued at a rate of 1 ROC per MWh and are worth about £34 each.

LECS are issued as credits against Climate Change Levy at the rate of about £4.30 per MW.

Therefore if the installation was approved to supply the national grid through one of the national supply companies the producer could qualify for a net sum of £38.30 per MW.

100,000 kW over 3.5 years = 28500 kW per year = 28.5 MW per year

Value per ROCs and LECs = £38.30 / MW

Total value of electricity fed back into the grid = £1091

Cost of actual electricity purchased = 8 p / kW = £2280

Installation cost = £83000 over 20 year depreciation

Cost per kW = 14.5p (excluding any maintenance)

Return on capital = 1.3%

6.2.2.2 Summary

- Photovoltaic panels can utilize available roof space.
- The panels are usually modular for easy installation and addition.
- All solar panels are subject to loss of efficiency from dust.
- Photovoltaic panels are more robust and flexible than solar thermal for large commercial installations.
- All solar panels are subject to loss of efficiency from latitude in UK.
- The current structure for electricity generation on farm does not warrant the installation of photovoltaic panels.

- On farm generation of electricity in the UK, especially in very rural areas is in need of revue. In my understanding there are physical limitations of introducing power at the edges of our national network to feed back in and across to other users, which will restrict the implementation of all forms of on farm electrical generation. The power supply companies have an obligation under their agreement with the government to meet the target of 10% generation from renewable resources by 2010, but it is easier for them to do so by large scale wind farms etc.

- There is no doubt, that farmers who can harvest their energy from renewable resources by whatever means, will contribute towards reducing their environmental foot print but the technology has to be affordable and has to be scrutinized against sound science or be made attractive through national assistance.

7.0 Energy Conservation

.The 1st law of Thermodynamics states that "Energy can neither be created nor destroyed". This is also referred to as the Law of Energy Conservation. We can change the type of energy to suit our requirement and we can harness energy that we may not have done previously but we cannot create it. It is therefore irresponsible and inefficient to waste energy, no matter what the source.

In order therefore to make a significant contribution toward reducing ones environmental impact any measure that will lower energy requirements, without compromising performance unnecessarily, should be considered and of all the technologies, these measures usually deliver the most direct return on investments.

The opportunities however to invest in energy conservation technologies is often determined by economies of scale.

7.1 Low energy electrical equipment

Below is breakdown of the electrical requirements for a typical cage layer house (60,000birds)

Equipment	Number of units	Power per unit	Total kW	Hours per wk	Total kW per week
Lights	445	25W	11.1	98	1087
Fans	44	0.75kW	33	100 (60%)	3300
Egg belt motors	7	0.37kW	2.6	35	91
Egg elevators	7	0.37kW	2.6	35	91
Feeders	26	0.75kW	19.5	21	410
Augers	2	0.75kW	1.5	14	21
Manure belts	14	0.57 kW	7.9	5	39.5
Cross conveyor	1	2.55 kW	2.55	5	12.75
Muck elevator	1	2.55 kW	2.55	5	12.75
Air mixer	2	11 kW	22	168	3696

The major electrical consuming components in a typical poultry house are the lights and the ventilation.

7.1.1 Ventilation

In an a extreme situation resorting to natural ventilation would avoid the need for the any fans at all but I believe this to be a false economy in the overall scheme of environmental management.

In certain climatic conditions the use of open sided houses, does enable buildings to operate with minimal circulation or no fans, but such conditions are not prevalent in the UK. Likewise I am not convinced, that even in these conditions, the environment for the birds is optimised at all times and therefore, is the net benefit of the need to save energy lost elsewhere?

Naturally ventilated buildings where temperature is critical for optimum performance, require tight management and special design to cope with climatic change. They also require relatively constant internal physical conditions. In my experience the installation of natural ventilation on free range systems for example, is immediately compromised by the necessary use of the pop holes and no sophisticated control system can accommodate the relatively large volumes of air available at low level. The necessary sophistication to control natural ventilation is seldom, if ever fitted for this reason and even without pop holes, is likely to be unjustifiable in the sort of semi intensive systems that would otherwise consider using natural ventilation.

In the UK and northern Europe the output of moisture, CO_2, dust and ammonia is roughly the same per bird within the same sector, maybe slightly higher in extensive systems which are less efficient. The lack of fans does not therefore; prevent the total discharge of atmospheric pollution from a flock, even if the concentration, measurable or visible from a fan is not apparent. Without some sort of assisted ventilation there are periods within the diurnal or annual cycle that that the environmental conditions within the building become detrimental to the welfare and maybe the performance of the flock. In the event of the need to actually control emissions fans will be essential.

There are already numerous control systems that allow ventilation to be controlled by temperature, humidity, pressure and minimum ventilation rates, however most conventional fans used in poultry units are designed to operate at full speed and minimal pressure. Variations from the set parameters reduce efficiency and/or increase power consumption. Operating a fan at half speed by voltage control will halve electrical demand but reduce output by more than 50%, likewise operating a fan in a situation with negative pressure or high back pressure will increase electrical demand and reduce efficiency.

The main purpose for ventilation in livestock buildings is to provide the required oxygen for the livestock, maintain the correct thermal environment and remove unwanted gas, odours and particles.

The requirement for oxygen is determined by the minimum ventilation rates and is relatively low in terms of the ventilation capacity of most buildings. It is also relatively static and only increasing inline with live weight.

Temperature control is largely determined by the relative humidity within the building and the ability of the animals to dissipate heat. This usually requires the largest proportion of the ventilation capacity of a building. Conversely in situations where heat is required, the temptation is to reduce ventilation to the point where humidity and minimal ventilation rates are compromised.

Removal of unwanted gases odours and particles is partly determined by the minimal ventilation rate but also on the design and layout of the building and its components.

If we could therefore control temperature by some other means we could dramatically reduce the need to ventilate at the rates we do.

7.1.1.1 Steinens, Neederweert, Netherlands

Steinan are a relatively small manufacturer of specialist fans and control systems for intensive livestock buildings. They are not alone in the use of frequency control as a means of controlling motor speed to reduce power consumption.

The principle of frequency control is to modify the frequency of the alternating current in the supply, with the effect that mechanical power of an electric motor is reduced exponentially rather than linearly as it would with voltage control. The supply is converted to 3 phase and the power can be reduced by the proportional reduction on each phase. Therefore a 1kW motor, at full power on standard AC frequency of 50 hertz will consume 1 kW and deliver its rated mechanical output. At 25 hertz; 50% of the normal frequency and at 50% of its mechanical output, its power consumption will only be 0.125kW (1 x 0.5 x 0.5 x 0.5).

Through correct design of fan and ventilation system, such that fans can deliver their rated out put at low speeds and without back pressure it is possible to dramatically reduce the overall power consumption of the shed.

Their proposed design would be series of inlet and exhaust fans, operated by frequency control that work in balance with each other to maintain a balanced pressure. Ventilation rates can be increased according to minimum ventilation requirements and temperature. As ventilation requirements increase, instead of running some fans at full power and others not at all, as would happen with conventional stage control, more fans would come on and maintain the power consumption below maximum.

Example:

If each fan can move 9800m^3/hr at maximum power of 0.75 kW

And minimum ventilation requires delivery of 39200m^3/hr

This could be supplied by 4 fans consuming 3kW

The same amount of air could be moved by 6 fans running at 66% consuming 1.3 kW

At the same time air distribution throughout the shed could be improved.

7.1.1.2 Inno Plus, Maasbree, Netherlands

This company specialises in the provision of emissions control equipment.

Their proposal for a fully integrated, energy efficient and environmentally sustainable ventilation system consisted of the following.

To design a ventilation system that only needs to provide the basic minimum ventilation for the stock by controlling the humidity, temperature and emissions separately.

The livestock building is designed with a passage way down either side. The ventilation is basically cross flow with fresh air entering from one passageway and exhausting through the other. On the intake side, fresh air is drawn through inlets in the outer wall under negative pressure, with the option to pass over cooling pads. The proportion of air through the cooling pads will be determined by the ambient temperature and the requirement of the livestock. On the inner wall the fresh air then has the option to pass over heating pads or pass directly into the livestock area under the same control as the cooling. Cooling is by water and heating can be from heat exchangers, ground source or direct. (Plate 8)

The air that enters the livestock building is therefore at the desired temperature and need only be at the volume to satisfy the physiological needs of the stock. The negative pressure inside the otherwise sealed livestock unit, is created by fans on the exhaust side in the other passageway. These are located at the end of the passageway in one bank and allow the installation of a compact 3 stage scrubbing system to remove dust ammonia and H_2S.

Any form of emissions control that involves passing air through liquids or filters and any restriction to air flow from cooling or heating pads, will increase back pressure and inefficiencies in the fans but fan design can accommodate this to a certain extent. The main feature of the system is that by dramatically reducing the total ventilation rate it enables a livestock building that would normally require 20 conventional 0.75 kW fans to operate with 6 x 1.5 kW fans, an energy saving from 15kW to 9kW.

Such technology does require a new building or serious adaptation of existing buildings.

7.1.2 Light

This represents the second largest consumer of power in a typical poultry shed and is one of the fundamental requirements for the welfare and performance of the stock, not only its intensity but its duration. There is little opportunity to reduce day length, although natural daylight is being encouraged in some systems and there is the scope to fit light detectors that will allow lights to switch off during the day if intensity is sufficient.

Poultry operations also require the ability to adjust light intensity for certain operations or to encourage particular behaviour and the frequency and colour of light can play a part in bird behaviour. Many layer operations have retained the use of traditional tungsten filament bulbs which give a “warm white” light and which are easily dimmable through voltage regulation. The intensity and type has not been so important in broilers.

In 2011 the sale of traditional tungsten filament incandescent bulbs will cease and already poultry farmers have tried to source alternatives. The sale of Compact Fluorescents (CFLs) has taken off with energy savings of up to 20%. An equivalent replacement 60w tungsten bulb requires only a 14w CFL. There are however limitations on the ability to dim CFLs and the majority deliver “cold white” light. There is evidence that the frequency produced by fluorescent tubes is more detectable by the bird than that from incandescent bulbs.

The use of high and low frequency fluorescent tubes , which can be installed behind diffusers has overcome the problem of dimming and light colour although from experience low frequency has limitations on dimming capacity. The energy savings remain at about 20% but replacement of tungsten bulbs on twin core cable is impossible and requires complete rewire in 4 cores to carry the signal.

Bulb manufacturers such as Osram and Megamann now manufacture CFL bulbs that will fit existing tungsten bulb sockets and which will dim through special dimmers. The bulbs are available in a range of colours and as with all CFLs have a longer life expectancy, some going to as much as 15,000 hours.

7.1.2.1 Megaman, Welwyn Garden City, Hertfordshire, UK

A Chinese manufacturing company of Compact Florescent bulbs and fittings that are now available in the UK.

A comparison of the cost of ownership of a Megaman CFL 11 w against equivalent tungsten

	Megaman	Tungsten
Wattage	11	40
lamp life	15000	2000
Lamp cost	£5.50	25p
Lamp cost after 15000 hrs	£5.50	£1.87
Energy cost after 15000 hrs	£16.50(1x11x15000x0.1/1000)	£60.00(1x40x15000x.1/1000)
Total cost of ownership	£22.00	£61.87

Quite apart from the obvious cost saving the company claims that for every 100 bulb installations the benefit to the environment is a reduction of 36kg of CO_2.

Disposal of fluorescent tubes has not been as environmentally friendly as tungsten. The tubes and bulbs have contained CFCs, mercury, lead and cadmium. Although the frequency of disposal is less Megaman have complied with Restrictions on the use of Hazardous Substances (RoHS) in Electrical Components and their manufacture has either eliminated the inclusion of these substances or reduced it to absolute minimums. Under the Waste Electronic Electrical Equipment (WEEE) Directive there is an obligation on behalf of the manufacturer to recover and recycle the gas and component parts.

7.1.3 Summary

- Avoiding the installation of equipment, whether it is fans or lights or specific environmental control facilities as a means of minimising electrical power consumption, is often a false economy in terms of net environmental contribution and social responsibility.
- It is better to search out opportunities to install or manage the best controls systems to deliver their most energy efficiency.
- Technology for the reduction of power consumption through frequency controllers and low energy equipment is readily at hand with new opportunities becoming available.
- Despite quite high initial costs payback terms are usually low.
- The benefits are tangible and make a noticeable difference to utility costs.

7.2 Air to Air heat exchangers

The poultry industry in the UK uses about 200,000,000 litres of propane or its equivalent each year to brood chicks. The process is usually through whole house heating, using direct air heaters.

Of the total amount of heat energy input into a building in a flock lifecycle, about 30% is radiated heat; it is absorbed by the birds, the litter, the floor and the fabric of the building. It may be possible to reduce this figure to about 25% by installing the highest levels of insulation, but conversely older buildings or those with a lower specification may lose up to 40%. Insulation is a classic example of the law of diminishing returns. Does the cost warrant the marginal improvement?

If we could completely seal the shed there is a potential to save the 70% of remaining energy input, but we have to ventilate not only for the sake of the livestock but to allow the burners to burn in sufficient oxygen. In temperate latitudes, air is introduced at ambient temperature which is below the set temperature required in the building and warm air is extracted to atmosphere. The consequence is that internal temperatures fall and heat is required to raise it again in a constant cycle. The cost of fuel for heating represents at least 50% of the producer's costs on a "managed margin" broiler contract. The consequence of heating by propane or kerosene is that for every litre of propane burnt 0.6 litres of water vapour is produced which raises relative humidity within the building and compromises litter quality. The effect therefore is a spiralling of heating costs accompanied by a deterioration of internal climate.

An air to air heat exchanger enables the hot air exhausted from the building to be passed around a set of ducts through which fresh air is passed. The heat is transferred to the fresh air and so enters the building at above ambient temperature.

7.2.1 Agro Supply, Meerheid, Netherlands

The use of technology that was originally designed for manure drying has been transferred to the brooding facilities for broilers. One of the objectives set out at the start was that the heat exchanger had to deliver genuine net benefits to the environment and to the farmer and so had to deliver savings in heat energy without unnecessary electrical consumption.

The units are 9m long and available in a range of widths to suit house size. The length is determined by the comparison of heat transfer against energy requirement. The longer the air currents pass one another, the greater the heat transfer potential but the longer air is forced through a tube, the higher the back pressure and therefore the power requirement of the fans. 8 m of tube was found to be the optimum. The unit is powered by 2 x 1.5 kW fans, one extracting the warm air from the building and the other introducing the fresh air. The buildings therefore run under balanced pressure which avoids the escape or entrance of air from outside. (Plate 9)

Unlike most ventilation systems which operate on temperature or on fixed settings the unit operates entirely on the minimum ventilation requirements of the growing birds. All conventional ventilation can be switched off, although for safety they are left on but with a higher margin of tolerance. A ventilation curve is set in the computer to deliver the minimum ventilation, based on an industry figure of 0.7m^3/kg /hr. All units will provide the minimum ventilation up to at least 14 days of age, by which time the majority of heating is completed. As body weight increases, so does ventilation, with the fans increasing in speed using frequency control, so that, not until they reach 100% of their capacity, will they be using their entire power requirement.

The units operate at about 80% thermal efficiency and so ambient temperatures of 5˚C; will be raised to about 23˚C before entering the house.

The reduction in the total burning hours of the heaters reduces moisture deposition and reduces CO_2 production; ventilation can be scaled back to only providing the requirements for the birds. This reduced ventilation in relation in comparison to a conventional system provides further opportunity to save a proportion of the 70% energy input. The pre-warmed fresh air is introduced into and distributed from the top of the building, providing a buffer for the rising heat from the heaters. The effect of air balanced and distributed in this way, within an otherwise sealed building is a net increase in temperature of about 1˚C, which will allow heat set points to be reduced. A heat exchanger operating at 80% efficiency with ambient air at 5˚C will recover over 120kW of energy. This is the equivalent of 2 standard propane heaters. The combined effect of these three features means that heating energy fuel costs can be reduced by 40-50%, with unquestionable environmental benefits.

The units can be installed on new and existing buildings; they do not affect any of the other operations on the farm or within the building, they are assembled as a stand alone unit and designed to be weather proof.

I was so impressed by the technology, not only how simple the concept is but the enormous benefit it can deliver that I calculated the potential environmental impact.

Of the 200,000,000 litres of propane consumed by the industry each year there is the potential to save 40% using heat exchangers.

For logistical reasons it is unrealistic that more than 50 % of the industry will be able to take up the new technology so we have a conservative potential saving of 40,000,000 litres per year.

Each litre of propane when burnt produces 1.569 kg of CO_2 and each kg of CO_2 is the equivalent of 0.27 kg pure Carbon. Therefore a saving 40,000,000 litres could reduce carbon emissions in the UK by nearly 17,000 tonnes per year.

Unfortunately new technology does not come cheap and a typical unit for a flock of 35000 broilers will cost about £25000 to install. This gives a payback in terms of gas alone of about 4 years at current gas prices. The energy savings are made without compromising bird welfare, in fact quite the opposite, with improvements in litter quality leading to lower hock burn and pododermatitis, potentially better FCR and bodyweight and reduced incidence of enteritis. There is scope for the technology to be used to help control diseases such as Mareks by allowing fresh air to be introduced to the building from a completely separate source than the main intakes where feather follicle dust may reside. The economic benefits of these welfare issues have not been evaluated.

Political recognition

It is a shame that technology such as this does not get the recognition I believe it deserves. Contributions towards national carbon emission reductions like this should compete with policies such as double glazing and insulation for financial assistance. I would not advocate that money is handed out directly to farmers to pay for such units but encouragement, in the form of access to favourable loans or the ability to offset the purchase against Climate Change Levy, would enable the industry to commit fully to climate change and more importantly, make a real contribution towards conserving fossil fuels. The Carbon Trust which is tasked with the role of managing the government's achievements in green house gas reduction cannot support agriculture because it is already a supported industry under CAP. I think poultry farmers across the country would like to see where their support is!

Despite this, the fact that we all share the same atmosphere and have to compete for the same resources when it comes to fossil fuels, any technology which can make a contribution should be encouraged.

7.2.2 Summary

- Air to air heat exchangers can deliver a genuine socially responsible solution to both welfare and environment.
- The technology does not rely on new build or specific building design and configuration.
- The savings on fuel can be made on any heating source.
- The energy recovered can be used in a variety of situations such as manure drying but also affiliated or neighbouring enterprises and even in industrial situations.
- The savings are genuine and achievable without reliance on additional or extraneous equipment and circumstances.
- The technology is relatively expensive but is related to the cost of heating fuel. In terms of environmental benefit however it is a "no brainer".

8.0 Odour and Emissions Control

Broiler units will emit varying amounts of ammonia from 40 – 120gms/b/yr (Average 80gms) from the same inputs depending on management and breed. Layers average about 125gms/b/yr. Dutch limits on ammonia emissions for new buildings are 45gms/b/yr. There is therefore a need to control this emission.

Dust is more difficult to measure and control. Particle size above 10µ can be easily captured but below that size is more difficult and it is difficult to determine the source. Dutch legislation expects units to produce no more than 1% above established background levels and German law insists that 90% of ALL dust is captured.

Odour is more emotive but is also more easily controlled.

There is a misconception brought on by the scale of operations, that intensive units create more of an impact than extensive. It is true that concentrations of manure and livestock pose their own problems but two issues must be taken into account. Firstly, in terms of units of output and efficiency the bigger units can actually in terms of mass balance deliver less of an impact than the smaller extensive ones. Secondly, economies of scale provide the opportunity to justify more elaborate emission control systems such as filters and scrubbers.

Many units in the USA had the option to drop curtain sides on their buildings to allow some natural ventilation and thereby save energy but in Europe the tendency is to build fully environmentally controlled buildings. Free range units restrict full environmental control by distorting temperature and air flow through pop holes and can lead to a deterioration of condition inside leading to greater ammonia production. Neither of these systems however prevents the pollutants from entering the atmosphere. If Environmental Impact Assessments or IPPC conditions require the reduction in emissions, some form of control has to be implemented.

The Environment Agency have modelled ammonia profiles from intensive livestock operations and imposed 100% reduction conditions on sites that are within 2 km of sites referred to as Sensitive Receptors , such SSSIs or AONBs. These sites either face closure or the installation of some form of control.

All forms of emissions control will add cost and their effectiveness will be largely proportional to their cost. Justification will be dependant on the severity of the problem and the conditions expected either by legal or local pressure. I suspect that in terms of Best Available Technology (BAT) under IPPC, some form of control will be necessary on all new installations.

A system as described in the section on fan efficiency, whereby ventilation is kept to a minimum by controlling temperature, means that the efficiency of emission control is maximised. Dry filters, chemical or bio filters can reduce emissions of ammonia for example by up to 98%.

8.1 Big Dutchman, Vechta, Germany

I visited the Big Dutchman main site and then a couple of local farms with Ulf Meyer to see what was on the market for emissions control.

In Germany and especially in the area around Osnabruck which has the highest concentration of livestock in Europe, every new livestock installation that comes within the 40,000 bird IPPC threshold has to install at least a dust filter and an emissions stack that exhausts at a minimum 15m above ground level.

8.1.1 The Dutchman Stuffnix filter

The system works by drawing all the air being exhausted from the building through a panel of corrugated cardboard. To increase surface area while maintaining filtration capacity and thereby keeping back pressure on the fans to a minimum the panels are mounted in a zig zag formation. This takes up to at least 1-2 m of building length when fitted to a tunnel ventilation system. Each panel has double corrugated layer with the air having to convolute through it. The speed of air flow is dramatically reduced allowing dust particles to settle out at the base. The system is completely dry and easy to maintain and clean but is only for the removal of dust and can reduce dust emissions by 70% (Plate 10)

Ammonia, H_2S and odours require wet and or chemical scrubbing

8.1.2 The Dutchman Magix scrubbers

The first stage, which can replace the dry filter above, is to pass the exhaust air through a wet filter with water only. Dust is trapped and washed out and increases the dust control to 100%.

The extraction of dust removes a proportion of ammonia and odours which was attached to the dust particles. For further ammonia control the air must be passed through a filter sprayed with sulphuric acid which converts the ammonia to ammonium sulphide, this is then neutralized with caustic soda and converted to harmless sulfate. The ammonium sulphide also has a value as an artificial liquid fertilizer.Odour-free air exits the stack to atmosphere. (Plate 11)

The whole system requires space and ventilation capacity can be severely restricted. It is best situated at the end of the building where there is the concentration of fans. It requires fairly complex pumping and nozzle systems and of course energy consumption. This is not the sort of technology that can be fitted to many existing buildings and is therefore restricted to new build.

The sulphuric acid stage, which itself neutralizes the ammonia can be followed by a biological filter. This is a simple water sprayed filter on which a bacterial culture is present. The biological filter will remove odour and avoids the need for chemical neutralization, but involves the same amount of energy in terms of air passing through filters.

8.2 Hagola Biofilters, Goldenstedt, Germany

If odour and dust are the only issues a simple biological filter was demonstrated in the Hagola System by Jorg Weiting.

This consisted of passing all the exhaust air through a bed of wood chippings which are kept damp by spraying with water. The construction of a frame or several frames into which the ventilation is ducted allows the filter to be fitted to existing buildings with more traditional side ventilation. The wood chips are suspended in nets above the chamber and are open to the atmosphere. In northern climates with sufficient rainfall, the wood chips are kept damp naturally and the nets allow easy removal and replacement. (Plate 12) Water can be sprayed onto the wood chips in dry conditions.

A bacterial culture, which does not require seeding will develop within the wood chips and is very effective at removing odour but will not remove ammonia except that trapped in dust particles.

8.3 Summary

- Emissions control may be a necessary requirement on some units.
- The ability to control the environment will enable one to control the emissions.
- No control does not mean fewer emissions. The production units (birds) produce the same emissions/unit they are just not as concentrated.
- All emissions control will be expensive to install and operate.
- Reducing the total ventilation will assist in the justification for emissions control and will reduce emissions in itself.
- It is usually the more intensive and larger units that can and will justify emissions control thereby confirming that intensive systems can be more sustainable than extensive.

9.0 Breed / Feed

The breeders have a part to play in environmental management

Firstly to return to the original criteria of measuring environmental impact in terms of unit of output, the breeders have been very successful over the years in improving efficiency. Numbers and mass of eggs per bird have increased and growth periods for table poultry have reduced while FCR has improved. These factors deliver genuine net environmental gain by reducing inputs.

I have linked feed and breed together as it is often the utilisation of feed by the birds that will deliver the effects. The availability of feed raw materials which have a lower environmental impact either in terms of the way they are grown or their origin globally, including the utilisation of by-products from other industries can only be exploited if the birds can make economic use of them.

Breeders are already selecting for traits that will have a direct environmental effect. The production of dry manure that will emit less ammonia is just one selection criteria.

Work carried out at Iowa State University by Professor Hongwei Xin has shown that white layers (Leghorns) the predominant breed in USA and indeed the world produce 500kg more ammonia per tonne of live weight compared to brown layers, but due to their better conversion ratio and out put are more efficient by 100kg per tonne. The potential for the brown layer to improve is faster than any further progress in white layers and the world trend seems to be towards brown.

The same trial to monitor but also reduce ammonia emissions has shown that a 1% reduction in crude protein in the diet will result in a 10% reduction in ammonia output. Likewise a 30-40% increase in the proportion of dietary fibre will reduce ammonia by the same but will lead to an increase in overall feed intake.

While discussing the potential for new feed ingredients with Neil O Sullivan, Head Geneticist at Hyline, Des Moins, Iowa and James Adams of Wenger Feeds, Harrisburg, Pennsylvania, there is scope to include materials that do not normally appear on least cost formulation matrices for poultry diets but which could give net benefits towards performance and the environment. Will this lead to the potential for ration formulation to be based on a “least environmental cost” to satisfy a particular market? We have already developed rations after all that meet market requirements for vegetarian diets which are not least cost.

There may well be the need for collaboration with vets and the pharmaceutical industry, to control or select out preconditions for poor FCR. From experience, I have seen individual layer flocks, with relatively poor performance consuming 160gms of feed per day against a standard of 135gms. Breed, bird health and feed could all play a part.

Selection of any genetic trait is seldom unique to the trait itself and there is often a compromise to be made. For example, selection to remove fish taint from eggs can increase feed consumption and bird live weight for no other benefits. Also, with relatively few primary breeders of commercial poultry in the world, any selection must be applicable to the total market, without having to maintain multiple pure lines. Priorities in different parts of the world vary but with the increase in the up take of brown layers in large markets like China and with the greater potential for brown layers to improve the speed of change towards more environmentally efficient production should increase.

The time lag between isolation of a required genetic trait and the delivery to market is a minimum of 2 years, with the potential that the priorities will change in that time. The breeders are looking about 15 years in advance and have seen the environment as becoming a major driver, but delivery of environmental benefits from the breed and feed industry is very closely linked with economic efficiency and so is constantly being driven by the market.

The use of genetic manipulation in plant breeding may allow the use of plants for poultry diets that are currently limited or uneconomic and already improvements in plant breeding are delivering options on the availability of some materials. Soya, the major source of vegetable protein for livestock rations is increasingly being grown in more temperate latitudes, with the chance to become less dependant on imports from the USA and Brazil.

Genetic manipulation of the livestock is technically possible and has the potential to dramatically improve the environmental impact of stock, whether it be through improved efficiency or to reduce unwanted by products, but the public is unlikely to accept such technology.

10.0 Cooperation

I see that there is enormous potential for cooperation within and between industries and sectors.

We have already seen some cooperation between the arable and poultry sector on the disposal of manure and waste to mutual benefit, but since much of the energy we use in the industry is in connection with the production or extraction of heat, it seems sensible to combine operations or facilities that can share these outputs.

In the UK, the public have always been very resistant to the development or encroachment of agricultural development into “their” countryside or back yard leading to the erection of poultry facilities closely well out of public view. The proximity of intensive livestock units to domestic and commercial facilities in Germany and Holland, indicate a different attitude that can lead to environmental benefits. One example now exists where there has been deliberate construction of a livestock unit within an industrial area for the distribution of heat.

For certain, development of livestock units close to the public may have to include the latest technology to mitigate odour and emissions, noise, pollution and bio-security risks, but these are all good environmental measures anyway. To be able to provide heat through heat exchangers or heat pumps for homes or offices, electricity for local communities, a potential labour source without travel and maybe a better understanding between the public and the industry are just a few advantages to be gained by proximity. Such communities are developing in countries like Austria and in Holland they are looking at linking livestock units with the glasshouse industry for heat. Such proximity may encourage better understanding not only of food production methods and to demonstrate how responsible the industry can be towards animal welfare and the environment but also that we must be always aware of the fact that our customers will expect us to always deliver to their expectation. I visited a broiler unit in Holland on which the units are situated right on the side of the road in the village. There is no farm fence or boundary to exclude the public and the farmer has built a small observation room so that the public can look into his production unit at will. He produces to no specialist welfare scheme but is proud of the system he operates.

An example of cooperation in Pennsylvania USA was a hatchery that had been developed on the edge but in very close proximity to a new housing development. Neither the local authority responsible for the housing or the hatchery could justify the provision of a suitable water treatment plant on their own, together it was possible.

I had heard about the farms in the Far East where poultry coexisted with other enterprises, perhaps controversially with fish or crocodiles feeding off the manure or carcases. At least in these situations the “waste” material was being put to a commercial use. These complexes also provided heat and power for the community of workers.

The idea of producing a form of biodiesel from poultry offal is a more environmentally friendly means of disposal than rendering or land fill provided the inputs do not outweigh the outcome.

11.0 Waste

I did not investigate in detail the options for the responsible disposal and recycling of waste materials other than those included in animal byproducts.

The industry however does use a range of products and materials within its various processes that can either create an impact or become available for a recycling option. Keyes trays and paper based packaging can help in the provision of fibre for composting or even biogas plants and can certainly add bulk to pure manure for biomass burning, while also ensuring a biosecure means of disposal. Wooden pallets that are not within some form of national circulation scheme such as Chep, can be chipped for the same purpose. There are already established plants for the provision of wood chip for the domestic wood stove business that utilize such pallets.

Segregation of waste and its subsequent disposal or recycling should be part of every producer's responsibility. There are facilities for the collection of most plastic, metal and glass. Some responsibility must be placed on government and local authorities to encourage and facilitate waste management and on manufacturers to consider the implications of what and how they supply their products.

While the legislation is well intended the reality of the Agricultural Waste Regulations often discourages good environmental practice.

12.0 Water management

Similar to the position with solar energy, the large roof space covering poultry units catches and diverts substantial quantities of precipitation.

Where this water would otherwise fall and soak away through the ground, the concentration and run off can lead to local flooding and water logging. Eventual discharge into a watercourse after it has collected quantities of material from yards; pits and shed surrounds can lead to over nitrification or deoxygygenation.

The ironical issue however, is that the cyclical demand for water in poultry will often require high use or even importation of water for washing down at the same time or soon after a natural deluge. Would it not be better to capture and utilise what water we can?

It is unlikely that in the UK climate at present we will need to preserve or be able to use all the precipitation that falls on the farm within the year. Water however especially quality drinking water is likely to become a more valuable commodity. It is unnecessary to purify all the water that we do in the UK when a large proportion can be utilised as so called grey water. Climate change and demand from an increasingly urbanised population and industry is leading towards more frequent restrictions on water utilisation and costs will inevitably rise.

Water for drinking will obviously need to be kept pure but what I saw in the USA both with the wet flush systems under cages and the use of grey water to wash down milking parlours demonstrates that we could be doing more.

IPPC legislation will encourage the separation of contaminated water direct into water courses by insisting on catchment tanks, but usually the tanks are only a catchment for subsequent dispersal onto the land and receive water from both roofs and floors. It may, but need not necessarily rely on new build to incorporate the required drains, tanks and silt traps, that will enable roof water to be collected separately. In North Carolina for example the development of artificial wetlands for wildlife that also serve as the reservoir and filter for whole farm operations are now a common prerequisite for planning consent.

13.0 Conclusions and Recommendations from my study

1. It is a shame that we cannot demonstrate openly how good we already are in terms of delivering valuable food in the most environmentally responsible manner.

2. In the light of the Cranfield study we should be relabeling our products as “environmentally friendly” instead of intensive or standard to differentiate it from extensive, free range, or organic.

3. Welfare is a very emotive and subjective topic. It is also the privilege of the affluent society. We cannot ignore nor condone poor welfare, but we have to find a balance of “Social Responsibility” between food production, welfare and the environment.

4. More intensive systems which can deliver productivity with economies of scale and net environmental returns should be championed. Colony cages and multi tier systems for both layers and broilers are part of that process.

5. There is no single solution to reducing a poultry operation’s environmental impact.

6. It will depend on the geography and topography of the region.

7. It will depend on the financial and market forces at the time and the priorities placed on environment and other constraints.

8. It will depend on the personal or public perception of the producer or population.

9. It will depend on the current legislation in force or expected.

10. It will depend on the levels of skill or available technology that will ensure a net gain is achieved.

11. Each operation has to review its own practices, circumstances and objectives and implement a range or adopt a single technique that suits its own purpose. Where common best environmental practices also reduce cost, the objectives are likely to be similar.

12. The true benefits to the environment are likely to be a combination of measures with each element making a contribution. Assessors of environmental impact must be aware of this fact and not expect blanket solutions.

13. All the basic technology is out there, and some of it has been around for some time, it may need a bit of refining to match our own requirements or to meet current practices and legislation but we don’t have to reinvent the wheel.

14. We should determine “best” practice only on the basis of sound science and then ensure the message is conveyed.

15. “Best” environmental practice must be measured against units of output (impact / doz eggs or impact /kg meat) and should be calculated on the net impact.

16. "Best" environmental practice has to include being economically viable. The best incentive for environmental improvement is when there is a financial reward.

17. The rising cost of fuel and energy will mean that what has been expensive technology will become more affordable, desirable and necessary in time.

18. As we approach the mid 2010's with the implementation of the Welfare Directive complete, lobby attention will switch to environmental concerns. Customer pressure through the retailers will focus on sustainability. Those organisations able to demonstrate higher environmental credentials will secure the market.

19. Legislators must be made aware of the implications of their actions so as not to impose short term solutions that do not deliver long term net benefits.

20. Likewise legislation must take account of the national and global market. Restrictions and practices that may appear to deliver socially responsible or environmental benefits in one location may encourage development of practices with a greater environmental impact elsewhere, beyond our control. We MUST not export our industry to satisfy our conscience.

21. Unfortunately new technologies especially those that contribute to the environment with long term returns are relatively expensive and slow to be adopted in favour of more rapid or tangible results. We all know the long term consequences and the global implications of ignoring the environment and governments therefore MUST facilitate the adoption of new technology. Firstly it will assist them in achieving their national targets because the poultry industry is all part of the same environment and should not be excluded just because it falls under a category of industry that politically has low democratic appeal or is supported in some other way. Secondly, without assistance being available now demand will be low, technology will be slower to develop and the subsequent delay in implementation will allow the situation to get even worse. Do we have to wait for fuel costs, driven by scarcity of supply to rise high enough, to justify investment when the responsible attitude would be to preserve what we have? These high costs and investments will inevitably and unpopularly be passed onto the consumer although probably not before the producer has suffered the effects of low returns.

Appendices

Plates

Plate 1
End sets on cage unit with transfers to extra belts above the cages
Hersbruk Farms, Grand River Michigan USA

Plate 2
Drum type batch manure dryer
Agro Supply, Meerheide, Netherlands

Plate 3
Composting in polytunnels
Hyline Dallas Centre, Des Moins, Iowa USA

Plate 4
Field Scale windrow composting
Green Meadow Farms, Elsie, Michigan, USA

Plate 5
Volex Close Couple
Michigan State University, Lansing, Michigan, USA

Plate 6
Sophisticated composting facility using clamps with automatic conditioners
Michigan State University, Lansing, Michigan, USA

Plate 7
Photovoltaic cells (30Kw) on free range layer house
Vechta, Germany

Plate 8
Inside the intake side of ventilation corridor, showing cooling and heating pads in external (right) and internal (left) walls. NB notice the use of ground source heating in this instance
Inno Plus, Maasbree, Netherlands

Plate 9
2.5m air to air heat exchanger fitted to 60,000 bird broiler unit
Agro Supply, Meerheid, Netherlands

Plate 10
Dutchman Stuffnix dust extraction showing exhaust at min 15m above ground level
Vechta,Germany

Plate 11
Sulphuric Acid based chemical dust and odour scrubber
Vechta, Germany

Plate 12
Biofilter using wood chips suspended in nets to capture odours from a pig unit
Hagola Biofilters, Goldenstedt, Germany

Plates

Plate1

Plate 2


Plate 3


Plate 4


Plate 5


Plate 6

Plate 7

Plate 8

Plate 9

Plate 10


Plate 11


Plate 12

People and organizations visited

USA		
NAME	**POSITION**	**ORGANISATION**
John Greaves	President &CEO	Hyline International, Des Moins, Iowa
Dave Welch		Hyline International, Des Moins, Iowa
Jeffrey Armstrong	Dean	Michigan State University, Lansing, Michigan
Ajit Srivastava,	Chair, Dept of Biosystems and Agric Engineering	Michigan State University, Lansing, Michigan
Darcy Green	Owner/Manager	Green Meadow Farms, Elsie, Michigan
Dana Kirk	Biosystems and Composting	Michigan State University, Lansing, Michigan
Mohamed Moosa	Vice President	Herbruk Farms, Grand Rapids , Michigan
Professor Hongwei Xin	Dept Agricultural & Biosystems Engineering	Iowa State University, Ames, Iowa
Neil O Sullivan	Head Geneticist	Hyline International, Des Moins, Iowa
Fred Adams	CEO	Calmaine Foods,Jackson, Mississippi
Dolph Baker	President & Chief Operating Officer	Calmaine Foods,Jackson, Mississippi
Wil Webb	Director of Production	Calmaine Foods,Jackson, Mississippi
Bob Pike	General Manager	Braswell Foods, Nashville, North Carolina
Mike Williams	Director, Animal and Poultry Waste Mngmt Centre	North Carolina State University, Raleigh, North Carolina
Carl Whisenant	Manager, Animal and Poultry	North Carolina State University,

	Waste Mngmt Centre	Raleigh, North Carolina
John Classon	Assoc Professor, Waste Mgmnt & Resource Recovery	North Carolina State University, Raleigh, North Carolina
Richard Meck	North East Region Manager	Hyline North America, Elizabethtown, Pennsylvania
Randy Dumire	Genera Manager	Kreider Farms, Manheim, Pennsylvania
James Adams	President and CEO	Wenger Feeds, Rheems, Pennsylvania
Bill Achor	Consultant	Landstudies, Integrated Environmental Solutions, Lititz, Pennsylvania.

Europe		
NAME	**POSITION**	**ORGANISATION**
Bernhard Meyer zu Rheda	Head of Calculation	Envitec Biogas, Saerbeck, Germany
Verena Martinek	Technical Manager	Stirl Anlagentechnik,Krakow am See, Germany
Marlies Mensing		2G Energietechnik,Heek, Germany
Betti Underwood		Bltze/Strom Photovoltaic, Kolitzheim, Germany
Ulf Meyer	Sales Director	Big Dutchman, Vechta, Germany
Dr Brauckmann		Vechta University, Vechta, Germany
Jorg Weiting		Hagola Biofilters, Goldenstedt, Germany
Henk Haaring	Director	Dorset Milieutechniek,varsseveld,

		Netherlands
Dr Marko Ruis	Animal Sciences Group	Wageningen University ,Lelystad, Netherlands
Dr Imke de Boer	Animal Sciences Group	Wageningen University ,Lelystad, Netherlands
Ann Espeel		Ver Beek Hatchery
Stefan Baselmans	General Manager	Agro Supply, Meerheid, Netherlands
Eric Helmink	Marketing Director	Vencomatic, Meerheid, Netherlands
Adrian Kitching	Marketing Director	Megaman Lights Welwyn Gdn City, UK