Agriculture and Rural Development
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Dear Sinead

BIOMASS FUELLED POWER PLANT

I am writing in response to your letter of 24 March 2009 which sought views on the issue of alternative technologies referred to in objection reports to the Rose Energy application.

The Agri Food and Bio-Sciences Institute (AFBI) provides advice to DARD on technical and scientific issues. In response to your letter I asked AFBI to assess alternative technologies and the issues you raised.

I attach the scientific assessment produced by AFBI and I trust that this is helpful.

Yours Sincerely

Peter Scott

cc: Dr Sinclair Mayne
Brian Ervine

Planning application number S2008/0630/F

Assessment of technologies for the disposal of poultry litter.

Context In her letter (24 March 2009) to Mr Peter Scott (Environmental Policy, DARD), Ms Sinéad McEvoy of the Planning Service in Northern Ireland asked for DARD's views on the alternative technologies suggested by objectors to the Rose Energy application. These were summarised in the letter as anaerobic digestion, pelletising into fertiliser, gasification, autoclaving and quick wash.

The Agri Food and Bio Sciences Institute (AFBI) is a Non-Departmental Public Body, core funded by DARD to provide scientific research and services to government, non-governmental and commercial organisations. As part of this remit and when requested, AFBI answers queries and provides advice to DARD on scientific and technical issues associated with the Agri-Food sector in Northern Ireland. The above letter from Ms McEvoy was passed to the Chief Executive of AFBI for comment and the remainder of this document seeks to respond to the points raised by Ms McEvoy. Note all web references given were accessed on 10 April 2009.

Land application of poultry litter The need for an alternative to land spreading of manures for the poultry and pig sectors in Northern Ireland arises from the EU Nitrates Directive. The controls applied under the Nitrates Directive are to reduce and prevent water pollution from agricultural sources. Measures implemented through the Nitrates Action Programme Regulations include a limit of 170 kg organic manure Nitrogen/hectare/year that can be applied to the agricultural land on any one farm holding. The purpose of this limit is to prevent excess applications of manure which will result in nutrient losses to water and consequent pollution.

Virtually all poultry and pig farms will exceed this limit and therefore need to export poultry litter to other farms to comply with the Regulations. On many other farms the manure from cattle and sheep use up most or all of this allowance. Thus the organic nitrogen limit effectively restricts the area available for exporting excess manure from pig and poultry farms. There are additional constraints on the export of poultry manure as, to protect against spread of botulism from poultry litter to cattle, current DARD advice is that poultry litter should not be spread on land that will be grazed in the same year[1]. Given the prevalence of grass used for grazing in Northern Ireland and the small size of the arable sector, this is a significant constraint on finding suitable spread land for poultry litter.

A further problem arises from the high phosphorus (P) contents of poultry manures, relative to their nitrogen content. This means that, where applications of poultry litter are targeted to meet crop nitrogen demand, the applications will over-supply with P. Over the long term this over-supply will lead to appreciable increases in soil P and this increase is regarded as a causal factor for the widespread occurrence of eutrophication (nutrient enrichment) in lakes in Northern Ireland. The reversal of

eutrophication is required to meet the objectives of the Nitrates Directive and Water Framework Directive. Thus alternatives to land spreading for managing poultry litter are environmentally desirable in the context of Northern Ireland.

EGAUM and AFBI Against this background, DARD established an Expert Group on Alternative Uses of Manures (EGAUM) in 2005. The group was chaired by Dr McIlroy the Chief Scientific Officer of DARD (now the Chief Executive of AFBI). To assist the Group, DARD commissioned the Global Research Unit of AFBI to produce a technical report that reviewed various options for utilising manures – including those that were in a development stage. This report, known as the EGAUM Technical Report was published by AFBI in 2005[2].

This report was **not** produced to support the planning application by Rose Energy, nor any other proposal. Rather it aimed to highlight potential available technologies, and identify those with a proven capability, that would address the problems of excess nutrients faced by the pig and poultry sectors in Northern Ireland. The report concluded that a centrally located combustion plant is a viable alternative use for poultry litter in Northern Ireland.

Since the EGAUM Technical Report was produced, AFBI has established the Environment and Renewable Energy Centre at Hillsborough, which includes research on biomass crops appropriate for Northern Ireland and the potential benefits of anaerobic digestion of organic manures from farms. This research uses an anaerobic digester which has been newly installed at the Hillsborough site and currently is processing manure from the dairy herd at Hillsborough.

No specific projects on alternative uses of poultry litter have been undertaken, nor has AFBI been commissioned to undertake any such investigations. However as part of their professional development, research staff endeavour to monitor developing new technologies on an ongoing basis. This is achieved through regularly accessing peer reviewed papers in scientific journals and books, attending scientific and technical meetings, site visits and memberships of professional scientific organisations.

Current status Other than its use as a fertilser and as a fuel source, AFBI are aware of a number of proposals for obtaining added value from poultry litter. However these can be characterised as being at various stages of development and testing and none has been integrated into commercial poultry production. Some of these technologies could be applied at farm level. It is worth noting that those potential on-farm solutions which involve combustion would need to address the associated issue of environmental emissions. The cost of the technology required to do this may be prohibitive at farm level.

A key factor in all alternative technologies is suitable outlets for the end products of the process, which, for most alternatives, has been barely addressed. In addition, from a bio-security perspective, removing poultry litter entirely from the farm is the best way of reducing the risk of spreading disease. AFBI therefore has no evidence or recent information that would alter the original conclusion that a centrally located combustion plant is a viable alternative use for poultry litter in Northern Ireland.

Protecting the future Two papers prepared by objectors to the Rose Energy application have been provided, but only one of these proposes any alternative uses to the proposed use of poultry litter for combustion and power generation. These are contained in the paper entitled *Protecting the future* compiled by Prof. George Bain, Mr Michael McHugh and Ms Aileen Smith. Their paper includes a section on Alternative Technologies (pages 28-33) and, under the heading three studies (Section 6.2), refers to three reports:

- A feasibility study for a CHP plant produced by Integrated Energy Systems International and supported by InvestNI (referred to as the INI report).
- "a study commissioned from an Expert Group on Alternative Uses of Manures (EGAUM) by the Northern Ireland Minister for agriculture and Rural Development (March 2006);"
- A report commissioned by SNIFFER entitled *The Methods for Disposal or Processing of Waste Streams from Intensive Livestock Production in Scotland and Northern Ireland*.[3]

The first of these reports was apparently commissioned by the major poultry meat producers in Northern Ireland. AFBI had no part in its commissioning or production. The Global Research Unit, which compiled the EGAUM Technical Report, was not aware of its contents. As mentioned above the EGAUM Technical Report was a stand alone document and provided a review of the technical feasibility of potential options available for managing manures in Northern Ireland.

It is unclear from the text of *Protecting the future* whether its authors were aware of the EGAUM Technical Report produced by AFBI, as the date given in *Protecting the future* for the EGUAM Report is March 2006 whereas the EGAUM Technical Report produced by AFBI is dated December 2005. The assertion in *Protecting the future* that the EGAUM Report "simply took as its starting point the INI feasibility study" cannot be true as the Expert Group was in possession of the AFBI EGAUM Technical Report.

Protecting the future highlights three potential options for the alternative use of poultry litter in Northern Ireland. These are referenced back to the SNIFFER report although, as will be described later, these alternatives were also assessed in the EGAUM Technical Report.

The *Protecting the future* paper asserts that the "the SNIFFER report does not conclude --- that the only or even the best solution to disposing of poultry litter in Northern Ireland is a centralised power generation plant: the report also allows for (a) a number of small combustion plants, (b) composting and (c) pelletising into fertiliser".

The conflation of these three options together for poultry litter is however misleading as the only recommendation for poultry litter presented in the conclusions of the SNIFFER report is as follows: "it is recommended that combustion of poultry litter is adopted as an alternative utilisation for almost all litter produced in Northern Ireland". (Section 6.1, p76). This is prefaced by the statement that in "Northern Ireland there is a real possibility that combustion can deal with the surpluses in the medium term".

The recommendations for (b) composting and (c) pelletising into fertiliser, referred to in *Protecting the future* are included in the SNIFFER report as recommendations for manure from laying hens – not for poultry litter. Their applicability for layer manure reflects the higher moisture content of layer manure compared to poultry litter, which means that it is less suitable for combustion. The diversion of layer manure for mushroom compost proposed in the SNIFFER report reflected an assumption in the report that the use of poultry litter for combustion would have a knock-on impact on availability of poultry litter for the production of mushroom compost. The SNIFFER report may have under-estimated the volume of poultry litter produced in Northern Ireland, as it is based on annual broiler chicken production in 2003 of 76.8 million birds. At a weight of 2 kg per bird this equates to a broiler meat production of 153,600 tonnes in 2003. However, broiler meat output in 2003 was 177,900 tonnes with a further 21,700 tonnes of other poultry produced for meat. In 2008 broiler meat production was 222,000 tonnes[4].

Mushroom production

Currently it is estimated that 20% of poultry litter produced in Northern Ireland is used to manufacture mushroom compost[3]. Since 2003, mushroom production in Northern Ireland has been steady or in slight decline so there is no evidence that there will be an increased demand for compost[4]. Therefore there is no realistic basis for assuming that there is large potential demand for using the remaining excess poultry litter produced in Northern Ireland for mushroom compost.

Other approaches Under the heading *Other approaches* (Section 6.3) *Protecting the future* asserts that "the major alternatives to the incineration of poultry litter [are]: anaerobic digestion, pelletising into fertiliser and gasification." The following assessment relates to these alternatives.

Anaerobic Digestion The major disadvantage of using poultry litter in conventional anaerobic digestion (AD) is that, in order to operate effectively, the dry and easily transportable poultry litter has to be diluted with large volumes of water, or other liquid waste. This means that at the end of the process, a means has to be found of recycling to land the large volumes of liquid digestate created by the process. This digestate will contain the same quantities of plant nutrients as were in the feedstock – a sustainable use of the nitrogen, P and potash in the digestate will be required within the constraints on nutrient spreading highlighted above. On this basis anaerobic digestion does not address the fundamental issue of excess nutrients in the manure, as it requires land spreading of the digestate. Therefore, it is not an alternative to land spreading.

Specific issues relating to use of poultry litter in AD are as follows:

- Poultry litter has a high nitrogen content, which can inhibit the anaerobic digestion process.
- As highlighted above, conventional anaerobic digestion requires feedstocks in the range of 10-15% dry matter (DM) content (to facilitate pumping in and out of the digester). Poultry litter dry matter content is usually in the range 41-98% (overall normal average of 60%). Consequently large volumes of water

or other liquid waste are required to bring the material to 10-15% dry matter. For example, 200,000 tonnes poultry litter at 60% DM will require 1 million tonnes or over 200 million gallons of water to bring it to 10% DM, or 600,000 tonnes water to bring it to 15% DM. One option could be to co-digest poultry litter with pig slurry (normal DM content of 4%). For example, 200,000 tonnes poultry litter would require 1.5 million tonnes pig slurry to bring it to 15% DM. (The total slurry produced by housed pigs in Northern Ireland is approximately 1.4 million tonnes).

- Assuming poultry litter is diluted as above, the primary challenge remains; namely to recycle the large volume of digestate to land as the digestate volume is only slightly less than the volume of feedstock.

There is some suggestion that "high dry matter" (30%+) anaerobic digestion is possible with poultry litter. AFBI has no knowledge or experience of these systems nor are we aware that poultry litter has been used in this process. If the process is possible, the problem of managing the nutrients in the AD digestate would remain after the litter had been processed.

Pelletisation. The *Protecting the future* paper highlights the potential for converting poultry litter into pellets that can sold as a fertiliser and refers to the facility operated by Perdue Agrirecycle which has adopted this approach. This plant has been operating since 2001 and is probably the largest in the world - AFBI is not aware of any other plant operating on this scale. Therefore there is no question that the process is technically and practically feasible. The question remains is it a financially prudent alternative to combustion for poultry litter? The answer depends on whether there is sufficient market for the distinctive product that the plant would produce.

Both the SNIFFER and EGAUM reports also gave prominence to this facility and there is no need to repeat the technical detail provided in these reports. In 2008, Dr Foy of AFBI visited the plant with a group of US and Canadian scientists who were given a presentation by the manager of the plant. With respect to the potential for establishing a similar plant in Northern Ireland, the following points can be made.

- The process is not a substitute for land spreading as the product will be applied to the land as a fertiliser. It would still be regarded as organic N under the Nitrates Directive and applications would be constrained by the 170 kg organic N/ ha limit and crop requirement.
- The fertiliser produced is quite unlike conventional fertilisers as it contains the organic matter in the poultry litter. The low nitrogen to phosphate ratio found in poultry litter also remains, so that, if applied to meet crop requirements for nitrogen, it will oversupply with P. The Microstart60 fertiliser produced by the plant in the US has a % formulation for nitrogen, phosphate and potash of 4%:2%:3%. By comparison the nutrient content of chemical fertilisers is much higher, roughly by a factor of 5 or more. Straight nitrogen fertilisers have a nitrogen content of 27% for calcium ammonium nitrate while urea has an nitrogen content of 46%. Thus, because the pelletised fertiliser is a dilute form of nutrients, its transport and spreading costs must be proportionally higher in

comparison to chemical fertiliser. There is no evidence that it is better in terms of crop yield per unit of fertilser nutrient applied compared to chemical fertilisers.

- There is no evidence that the Perdue products are used to any degree in conventional agriculture for cereal, maize or grass production. The company brochure makes no claims for this as an end use, but rather emphasises their product's use in golf courses where the organic matter in the manure is stated to be beneficial for improving water penetration and retention in soils, and the slow release properties of the nutrients. The pelletised fertiliser is also promoted for use in vegetable production and has received an organic certification in the US. Whether this would be possible in the UK is doubtful as much of poultry production in NI is based on non-organic certified feeds. http://www.perdueagrirecycle.com/pdf/MS60_Broch.pdf
- The impression was given that golf courses in states such as Florida were a key market and that the Perdue plant supplied most of home gardening demand for organic fertilisers sold in the US. These specialist outlets for pelletised poultry litter raise questions as to the scale of the demand for the pelletised product in the USA and UK-Europe. The Perdue plant is the largest in the world but this does not mean that its output is large in terms of poultry manure production. It has a capacity of 90,000 tons per year but operates at around 70,000 tons per year. By comparison a new power plant in Minnesota will require 500,000 tonnes of turkey litter. (http://www.fibrowattusa.com/).
- Poultry litter production in Northern Ireland is in the region of 200,000 tonnes per year. Yet, based on a throughput of 70,000 tons per year, the Perdue plant has a large market share for pelletised products in the US, which is a nation of some 300 million citizens, roughly the same as western Europe. If the US demand for the pelletised product can be met by the Perdue plant, there is a real doubt for the product demand within UK and possibly Europe from a much larger plant which would be required to pelletise most of the poultry litter produced in Northern Ireland.

Creative Chicken Company Despite being in operation since 2001 no other fertiliser pelletisation plant operates to the same scale as the Perdue plant. *Protecting the future* refers positively to a plan by the Creative Chicken Company to construct a pelletisation plant in Arkansas or Oklahoma. If as stated on the company web site, the plant was to process 100 tonnes of poultry litter per hour, the projected annual output from the planned plant equates to around 190,000 tons per year or 3 times the Perdue Agrirecycle consumption.

In fact the Creative Chicken Company is a rather ephemeral entity. Currently it is for sale on Craigs List where it is described as having "no baggage, buildings, machinery or equipment to hinder the takeover, and no hourly employees to sever". http://london.craigslist.co.uk/bfs/1082901625.html

In 2008 it was ordered to cease using its web site to sell stock or shares for which it was unlicensed to sell in Arkansas. http://www.securities.arkansas.gov/!userfiles/S-08-049-08-CD01.pdf

An examination of the composition of the Advisory Broad profiles on the Creative Chicken web pages shows that the board has very limited professional relationships with the poultry, fertiliser, horticulture, golf or power generation sectors in the US. http://www.creativeconsultant.org/home.html

At best Creative Chicken Company is not a serious player in the management of poultry litter.

Gasification. In combination with pyrolosis this technology relies on heating organic materials in controlled and reduced air flows to high temperatures. Gases such as methane and carbon monoxide are produced as well as a bio-oil residue, all of which have value as energy sources. Some of this energy output is required to operate the heating process. These technologies were reviewed by the EGAUM report and, given their developmental status and very limited application to poultry litter, none was recommended. There is little that can be added to this conclusion.

Through contact with a company in the Republic of Ireland (Energy Flow Ireland) AFBI are aware of a Canadian Company, Advanced Biorefinery Inc. who are testing this technology for processing poultry litter at an on-farm scale in Nova Scotia. (http://www.advbiorefineryinc.ca/home/) A document describing the process can be accessed at http://www.advbiorefineryinc.ca/media/MM_ABRI_BIOOIL.pdf.

The process remains obviously at the development scale so cannot be regarded as a turn-key approach within Northern Ireland. From the information available a number of points are relevant.

- A bio-char residue of approximately 25% of the starting biomass remains and this contains most of the original organic nitrogen and phosphorus in the poultry litter. The Canadian experience suggests that, compared to poultry litter, bio-char is more unbalanced as a source of plant nutrients with respect to its unfavourable N:P ratio.
- The bio-char has to be utilised or otherwise disposed of and, if land spread, will encounter the regulatory constraints associated with the Nitrates Directive for poultry litter. The nutrient contents of the bio-char are not dissimilar to that of the pelletised poultry litter described earlier, so bio-char is a dilute nutrient fertiliser in comparison to chemical fertilsers, leading to high transport and land application costs. In contrast to pelletised poultry litter, its efficacy as a fertilser remains to be determined in terms of availability of nutrients and crop yields. The carbon in the material may have value as a soil quality amendment.
- The bio-oil produced is quite unlike fuel oils such as heating oil or diesel that are encountered in everyday life. It has been described as “generally unstable, acidic, corrosive, viscous, and includes both water and ash contents”.[5] Current utilisation relies on gasification of the bio-oil to carbon monoxide and hydrogen for combustion in a diesel generator. As noted

earlier, the emissions from such a fuel system may be an environmental issue and the ability to safely manage a system based on carbon monoxide production on a farm scale would have to be carefully considered,

- The requirement for further development of bio-oil potential was recognised by the UK Carbon Trust in their 2008 call for proposals to improve current pyrolosis technologies: The preamble to the call states “Pyrolysis of oil from sustainable sources of biomass is a potential source of low-cost fuels with low system greenhouse gas (GHG) emissions, if it could be integrated into the existing transport fuel supply chain. However, the properties of the oil produced from current fast pyrolysis processes are unsuitable for direct integration. The Pyrolysis Challenge has the objective of producing oil with the properties required for integration through:
    - modifying the pyrolysis process to produce better quality oil directly, or
    - upgrading the oil before or at the refinery.”

http://www.carbontrust.co.uk/technology/directedresearch/pyrolysis_challenge.htm

Autoclaving. Autoclaving is a form of sterilisation in which material is heated under steam pressure to temperatures above 100°C, which achieves a rapid sterilisation. It has no application at all to the management of poultry litter.

An autoclaving stage was apparently included in a waste management process for household waste, which was then proposed as an alternative to combustion for poultry litter. For the household waste, autoclaving has to be undertaken before potentially recyclable materials are mechanically extracted from the waste. The extracted and hopefully sterilised waste would therefore be more easily managed and recycled. The remaining material would then be subjected to pyrolosis to extract methane and bio-oil as described above.

As there is no material in poultry litter than can be mechanically extracted the proposal to steam sterilise 200,000 tonnes of litter before heating it during pyrolosis to 500°C is utterly pointless – if only on the basis that pathogen destruction will be much more complete in the latter process.

Quickwash This is a process which has recently been proposed as a means of treating poultry litter by selectively removing phosphorus, which is recovered as calcium phosphate.[6] The treated solid therefore is selectively enriched with nitrogen, which lowers the risk of phosphate over-supply to soils described earlier. The process relies on washing the litter with an acid, which dissolves the phosphorus. The recovered acid is then neutralised with lime and a coagulant added to assist in the precipitation out of the phosphate.

Thus there are three products from the process: the P depleted poultry litter, calcium phosphate and the neutralised quick wash solution. The process is obviously innovative and brings fresh thinking to the problem of poultry litter management. However the process remains untested at any practical scale. There are number of issues associated with the management of the process and products produced which

would have to be resolved before it could be recommended as appropriate to the Northern Ireland situation. Some of these are outlined below.

- Applying the P depleted poultry litter would still face the organic nitrogen constraints set out earlier associated with the Nitrates Directive and perhaps also those associated with botulism.
- The effluent from the process has significant amounts of nitrogen in it. (In the region of 25% of the nitrogen in the poultry litter is extracted by the acid quick wash compared to +80% of the phosphorus). Even after the phosphorus was recovered, this effluent would also face the constraints posed by the Nitrates Directive as it could only be applied to land within the organic N limit. It would also require the provision of storage during the closed periods for applications of manures and fertilsers to land.
- The calcium phosphate recovered is the only tangible added value product, but the practicality of defining an outlet for this within the bulk commodity business of fertilisers in Northern Ireland has to be established. Costs given for the US estimate the value of the phosphate recovered at $63 per ton of litter treated with chemical costs of $44 ton of litter treated. This leaves only a small margin to cover the costs of capital, labour and energy that the process requires. There would seem to be extra land application costs associated with the liquid effluent, while the acidified poultry litter may pose unique problems in handling and application. In the US budget, the economics were stated to be substantially favoured by water quality credits for poultry operations in the catchment of Chesapeake Bay which were quoted as $78 per ton of litter treated. These credits are obviously not applicable to Northern Ireland.

Conclusions

Having considered the alternative tecnologies suggested by objectors to the Rose Energy application, referred to in the letter from Ms McEvoy, the following conclusions can be drawn:

In addition to its use as a fertilser and as a fuel source, a number of alternative proposals for obtaining added value from poultry litter have been identified. However, all of these alternatives can be characterised as being at various stages of development and testing and none has been integrated into commercial poultry production. Some of the technologies could be applied at farm level, but those which involve combustion would need to address the associated issue of environmental emissions. The cost of the technology required to do this may be prohibitive at farm level.

A key factor in all of the alternative technologies proposed is to identify suitable outlets for the end products of the process, which, for most alternatives, has been barely addressed. In addition, from a bio-security perspective, removing poultry litter entirely from the farm is the best way of reducing the risk of spreading disease.

AFBI therefore concludes that there is no evidence or recent information that would alter the original conclusion of the EGAUM Technical Report (published in 2005) that a centrally located combustion plant is a viable alternative use for poultry litter in Northern Ireland.

References

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