Defra GHG Platform Project AC0114: User Requirements Workshop

Workshop Proceedings

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1. Introduction

The current United Kingdom (UK) Greenhouse Gas (GHG) Inventory for Agriculture estimates emissions of nitrous oxide and methane from soils, manure and enteric sources by integration of generic emissions factors (on a per head of livestock, hectare of land, or kilogram of fertiliser basis) with national agricultural census, fertiliser use and farm practice survey data. A more detailed methodology is required in which UK-specific emission factors are integrated with detailed agricultural data that map regional and sector differences in farm practice that affect emissions, and which can track the adoption of mitigation methods by the industry. The tracking of the voluntary adoption of mitigation methods supported by the industry Road Maps and Action Plans is a policy priority, and this would enable an improved Inventory to be used to forecast and monitor progress against country specific targets for reducing GHG emissions by 2020.

Defra project AC0114 (part of the GHG Platform) is tasked with developing a revised Inventory methodology that better represents the structure of the industry and

supports sectoral and spatial disaggregation of the data. It will be based on the linkage of national and regional statistics collected by government and stakeholders.

A workshop was held on 9th March 2011 at the Best Western Westley Hotel, Birmingham, for stakeholders to discuss initial proposals for the disaggregation of the UK agricultural sector into representative farming systems. The farm systems would form the structure for the future collection of statistics on baseline farm practice and the monitoring of technical innovation and adoption of mitigation methods. The main objectives of this workshop were to:

- Present and critically review the within sector farming systems that require characterisation to represent the breadth of each agricultural sector adequately;
- Identify mitigation methods that should be explicitly represented in the improved Inventory methodology; and
- Hear about industry plans and polices in the Devolved Administrations for reducing GHG emissions from agriculture and how the inventory on Land Use, Land Use Change and Forestry (LULUCF) complements the Agricultural GHG Inventory.

The workshop was also an opportunity to develop positive working relationships between industry representatives and the members of the AC0114 team. The workshop planning was led by Laurence Smith (WP 6) with considerable support from Tom Misselbrook (WP 1), Adrian Williams (WP 3) and Steven Anthony (WP 6). The workshop was attended by 58 delegates from industry and government

The Devolved Administrations were represented by members of the Wales Assembly Government and the Scottish Government. A representative from the Department of Agriculture and Rural Development in Northern Ireland (DARDNI) was unfortunately unable to attend due to a significant policy event in Northern Ireland on the same day. However, a presentation was given on their behalf after consultation with DARDNI.

The workshop was organised in three phases. The first phase consisted of an introduction to the Greenhouse Gas Platform projects by Steven Anthony (AC0114 Project Manager) followed by presentations from industry and the Devolved Administrations on their plans for achieving reductions in GHG emissions. The second phase consisted of a presentation on proposals for farming systems by Adrian Williams (WP 3) followed by table discussions and reporting back on the adequacy of the proposals. The third phase consisted of presentations on proposals for representation of on-farm mitigation methods by Tom Misselbrook (WP 1) and the mitigation methods captured by the parallel Land Use, Land Use Change and Forestry (LULUCF) Inventory by Amanda Thomson. This was followed by table discussions and reporting back on specific mitigation methods to be explicitly represented in the improved Inventory. All of the table discussions were structured by farming system and involved groups of mixed expertise on data, science and agricultural systems.

2. Coordination

The workshop was introduced and chaired by Laurence Smith. A voice recording was made of all presentations.

3. Brief Introduction to the GHG Platform

Steven Anthony (AC0114 Project Manager) presented on the background to the GHG Platform and the types of work planned under the partner projects

Agriculture is presently responsible for c. 8% of UK GHG emissions. The most important agricultural emissions are enteric methane and nitrous oxide from soils and manure management. The existing Inventory emission calculations are largely based on generic emission coefficients that are not specific to UK agricultural practice and are not sensitive to the anticipated changes in UK agriculture. There is therefore a need to improve the structure and calculations used by the Inventory to monitor and forecast progress in planned reductions in GHG emissions for agricultural sectors and regions of the UK. The UK Government has therefore commissioned a programme of research to develop an improved Inventory methodology. The core of the programme consists of three linked projects and is named the GHG Platform.

Two experimental projects seek to carry out extensive measurements of methane and nitrous oxide emissions on UK farms to derive emission coefficients that are representative of UK farm practice and more importantly are representative of the broad range of farm management systems and soil and climate conditions that affect emissions. The nitrous oxide monitoring project will also carry out work to verify emission calculations at the farm and landscape scale. A third project will integrate the new experimental evidence with existing data and national agri-environment data sets to develop an improved emission calculation and reporting methodology with improved spatial, temporal and sector disaggregation. Most critically, this third project is tasked with characterising regional farm practices and enhancing the Inventory methodology to explicitly represent their effect so that it will be possible to calculate the impact of technical innovation and uptake of mitigation methods by the industry. Supported by the development of a methodology for quantifying the uncertainty in emission calculations, this will enable the improved Inventory to function as a forecasting and performance monitoring tool.

The GHG Platform programme is being delivered by a partnership of 16 universities and institutes that is representative of agricultural and scientific knowledge across the UK. The programme is, however, also dependent on knowledge, expertise and data provided by the agricultural industry and we have therefore planned for a programme of consultative workshops.

The objectives of the improved Inventory project can be summarised as:

- Integrating country-specific emission factors and regional agricultural statistics to enable an improved Inventory of nitrous oxide and methane emissions for the UK with an assessment of uncertainty;

- Mapping regional and sector differences in farm practice, and tracking the adoption of mitigation methods by the industry; and

- Enabling the Inventory to function as a forecasting and performance monitoring tool with respect to targets for emission reductions.

4. Perspectives on Planned Reductions in GHG Emissions

Representatives from the agricultural industry and the Devolved Administrations were invited to give presentations on their perspectives on and plans for reducing GHG emissions from agriculture.

4.1 Jane Salter – Agriculture Industries Confederation

Presented on the England Greenhouse Gas Action plan, providing an overview of actions and changes of practice expected from the agricultural industry, and emphasising the interactions expected with Defra and the AC0114 delivery team.

The Low Carbon Transition Plan[1] was published in 2009 and sets a GHG reduction target of 3 Mt CO_2e by 2018-2022. There are a number of challenges in delivering the objective in agriculture. These include the technical difficulty in reducing emissions in complex farm and food production systems; the wide diversity of farm types; the difficulty of motivating and recording change in farm practice; and the difficulty of estimating the impact of the changes in practice on GHG emissions at a suitable resolution. The agricultural industry has committed to a voluntary approach to secure this reduction without compromising domestic production and a Framework for Action was published in February 2010. A first phase Delivery Plan detailing milestones to 2012 is due to be published in April 2011. All of the key UK agricultural advisory organisations are involved in this project. The objective is to meet the CO_2 target through 15 on-farm actions and working with the AC0114 delivery team to define the key data for monitoring changes in practice and calculating reductions in emissions.

The areas to be focussed upon include crop nutrient management; soil and land management; livestock nutrition; livestock health; energy efficiency; and management skills and advice. Considerable effort is to be placed on improving communication and coordination between established organisations. The GHGAP plans to build upon existing initiatives and road maps for encouraging greater on farm efficiency - using established advisory channels and covering the full range of on-farm actions. Example partnership activities include the 'Campaign for the Farmed Environment' and 'Professional Nutrient Management'. Business to business activities were high lighted as a source of farm practice and verification data. A two way data flow between industry and government / contractors is necessary for the successful delivery of the Action Plan and the Improved Inventory. It is therefore critical that the data are afforded appropriate protection of IP and confidentiality. There may be considerable value of the data collected for a wide range of policy issues other than greenhouse gases.

4.2 Antje Branding – Scottish Government

Presented on the Climate Change (Scotland) Act 2009 and the Scottish policy background on Agricultural and Climate Change

[1] The Low Carbon Transition Plan was published under the previous administration; the present Government (July 2011) have not endorsed the report nor have they agreed to set targets for individual sectors

It was emphasised that Climate Change policy was a Devolved Administrative matter - so domestic legislation is critical to the delivery of domestic targets. The natural resource in Scotland is different to the wider UK - such as the extent of upland grazing and the potential carbon store - so domestic priorities are different. The Climate Change Scotland Act requires a 42% reduction in CO_2e reductions by 2020 and 80% by 2050. The legislation also requires that annual targets for emission reduction are set. The plan for emission reductions is also required for every sector. Agriculture and related land use are required to reduce emissions by 10% by 2020. In Scotland, emissions are reported for 'Agriculture and Related Land Use' that combines the Agricultural Inventory and elements of the LULUCF and Energy Inventories. The 'Farming for a Better Climate' initiative defines actions. It is also required by law that Scotland produces a Land Use Strategy in recognition of the many competing demands of land use and policy issues such as food production, urban development and forestry.

4.3 Dewi Jones – Wales Assembly Government

Presented briefly on the development of Agriculture and Land Use and Climate Change policy in Wales and the types of farming system in Wales.

Wales is committed to the UK Climate Change Act and additionally Wales has its own targets, including a 3% per year cut in emissions in areas of devolved competence from 2011. This is outlined in the "Climate Change Strategy for Wales" (October 2010). The Department for Environment and Sustainability and delegates to individual Departments have overall responsibility for climate change in Wales. The Department for Rural Affairs is advised by the independent 'Land Use Climate Change Group' (LUCGG). This group submitted a report in March 2010 outlining how reductions of 80% could be achieved by 2050. Five scenarios were investigated, including: 'business as usual' and "cut numbers of livestock". The favoured 'Scenario 5' involves: increased technical efficiency of livestock, more effective use of fertiliser and manures, widespread adoption of anaerobic digestion, methane capture from livestock housing (as an example of the type of necessary technical innovation required to achieve the 80% target), expansion of woodland area, and management of carbon stores. These actions would be delivered through the new sustainable land management scheme (Glastir); support for behavioural change through the Farming Connect Climate Change Development Centre programme; and the Dairy and Red Meat Roadmaps. Measures for supporting new woodland planting have already been announced.

The majority of Wales (c 80% - 1.7m ha) is given over to agriculture. 24% of the agricultural land area is classified as rough grazing and has significant value for ecosystem services. 60% is classified as permanent grassland – much of which is known as Ffridd - that is seldom cultivated and sustains higher levels of livestock in response to modest inputs of lime and fertiliser. Only 11% of the agricultural area is cultivated, with only under half of this area given over to arable crops. There is little information about land management in Wales. The BSFP does not have adequate coverage of Wales (it also does not cover Northern Ireland) and very little is known about manure management practices. Some more information is known about the meat supply chains.

4.4 Catherine Watson – Agri Food and Biosciences Institute, speaking on behalf of the Department of Agriculture and Rural Development, Northern Ireland (DARD-NI)

Grazed grassland is the dominant land use in Northern Ireland and 42% of the farmed land area is in Agri-Environment Schemes. Meat and dairy products dominate agricultural output. Although only 13% of farms in Northern Ireland are dairy farms the dairy sector is the most important sector in the Northern Ireland economy. The majority of beef and dairy products are exported to Great Britain. Calcium ammonium nitrate (CAN) fertiliser is the dominant nitrogen fertiliser type in Northern Ireland, in contrast to ammonium nitrate (AN) in England and Wales. The major soil types are poor draining and have significant potential for denitrification and nitrous oxide emissions, due to the mild wet climate. Also, 95% of the manure is managed as slurry. A farm nutrient management scheme (worth over £200m) operated from 2006 – 2008 and part financed up to 26 weeks slurry storage requirements to help farmers comply with total territory designation under the Nitrates Directive. A Manure Efficiency Technology Scheme (METS) is providing grant-aid for low trajectory slurry spreading technology.

A GHG Mitigation Framework consultation in 2011/12 will include work streams on research and development of advisory services to complement four key themes for mitigation: Nutrient management (optimising manures and efficient use of fertilisers); Livestock Management (genetic improvements, livestock nutrition, targeting of endemic and infectious diseases); Renewable Energy (use of AD, growing and utilisation of crops for biomass, improving fuel efficiency on farms); Land Management (development of future agri-environment schemes and enhancing carbon sequestration).

5. Presentation and Discussion of Farming Systems

5.1 Presentations

Adrian Williams presented an outline of the farming systems typology that is proposed to aid structuring the improved Inventory calculation methodology and emissions reporting. Slide titles are presented along with descriptions to support the contents

What we want to achieve

We need descriptions of farm systems to complement the revised emission factors (EFs) that will be derived from experimental and modelling work under the GHG Platform (projects AC0115 and AC0116). The farming systems need to be better disaggregated both spatially and temporally, e.g. N_2O from grazing livestock may occur throughout the year and on different soil types and in different climatic zones, while enteric CH_4 emissions may differ between seasonal diets. Systems must also allow mitigation options to be included. Systems must respond to changes in farming practice over time. We also seek better linking of GHG emissions (GHGE) and commodities, so that improved efficiency of production can be tracked.

The systems that we eventually define and apply must have supporting data to validate them. One critical aspect of this is that we may have high aspirations for the sophistication of systems that could be applied, but these must be tempered by the realities of data quality across the UK and disclosivity. The rules on disclosure will limit geographical disaggregation in some cases, especially when one or a small number of farms may dominate an area and thus be identifiable by unauthorised 3rd parties. The last point is diminishing returns. Small sectors will not receive the same improvement in the new Inventory as large ones, e.g. the emissions methodology for milking sheep is not likely to be changed.

In general, it is assumed that the systems described are not specific to parts of the UK, but the proportions will vary through geography as well as some social or economic influences.

Crops – dominance and data use

Emissions from nitrogen fertiliser applications are still likely to dominate the Inventory, but we are confident that we can do better than now. Part of this is improvement is to seek systematic variations by crop and location, which may link different sub-sets of N_2O EFs for one crop that another, e.g. potatoes vs. wheat and nitrogen application rates.

Data will be used for several purposes, e.g. yields and crop types are used to calculate arable residues that contribute to N_2O emissions. The same basic data types are used for organic carbon returns to soil in the LULUCF inventory. The land classes thus need to be co-ordinated with those in the LULUCF inventory. Nitrate leaching is also derived from yield, crop type and N application rates. Nitrate leaching leads to secondary N_2O emissions.

Annual crops

The approach to be taken here is that we have a set of annual crop types, e.g. combinable non-legume, that have generic properties and approaches to their management as well as specific differences. We then seek features of the crop management that are systematically linked with the crop. Most crops are grown with options in management, e.g. cultivation intensity or N rate and type. These are often influenced by soil type and/or climatic zone. Some practices are associated with crop destiny, e.g. late applications of urea for bread wheat or lower N rates for malting barley. The aim will be to identify systematic variations and associated them with crops, approaches etc.

Perennial crops

The main perennial crop types are orchards, fruit bushes and biomass. These will be treated in a similar way as annual crops, but there are cellar other management options for consideration, e.g. frequency of replanting.

Grass

The main grass types include rough grazing, permanent and rotational (in grassland-dominated and ley-arable systems). There are fewer management options to be considered, mainly N application rate, but other possibilities include the use of high sugar grasses and degree of clover in the sward. Most of these choices will be influenced by soil and climate.

Poultry: Eggs

This is a relatively simple example of animal production. The industry is organised by functions: breeders that produce chicks, pullet rearers that raise point of lay pullets from the chicks and laying flocks. These are mapped across to production systems such as caged, barn, free-range organic and non-organic) and free range may be rotational or not. Each system has a set of technical coefficients that define productivity, feed requirements etc and these are used to calculate N excretion rates, which will be associated with N_2O and NH_3 EFs for each system. There may be large differences in energy use between housing systems, the associated emissions do not

themselves feature in the agricultural inventory, although they are very relevant for product carbon footprinting.

Poultry: Broilers

The industry is organised by these main functions: broiler breeders that produce day old chicks, pullet rearers that produce pullets for the breeder flocks and commercial production flocks that take in day old chicks and produce finished broilers. The main options are again housing types: fully housed and free range (organic and non-organic).

Pigs

The main functions in pig production are: sows producing weaned piglets, weaned piglets taken to growers, growers taken to finishing and gilts (and fewer boars) retained for breeding. As with poultry, there are variations in housing system, with variations for the stocking density & rotational frequency of outdoor systems. Non-organic growers & finishers have the options for housing as sows (although most are fully housed), but there are general, systematic differences in liveweight finishing (pork, cutter & bacon weights) and thus ages (which are thus linked with time-dependent EFs). Organic production is most likely to be free range with integrated breeding and finishing.

Dairy

The main breakdown of the dairy herd is proposed to be three yield levels, each defined by average: yield, calving interval, age at 1st calving, mortality rates, lactation number and liveweight. These, in turn, lead to herd replacement rates and numbers of calves available for finishing as beef. The main management options relate to calving season (spring, autumn or all year), the grazing days, housing and hence manure (slurry and FYM proportions) and maize or grass silage. These are often influenced by soils and climate. It is expected that organic dairying will be represented by a parallel set, but with some systematically different proportions.

Beef

Beef production is broadly represented by calf production systems and finishing systems. Apart from crossed calves from the dairy herd, the main non-organic breeding systems are upland and lowland sucklers with autumn or spring calving. Finishing may range from 11 to 24 months and it is proposed to divide these into two month bands. The shortest finishing times are associated with high concentrate diets and sometimes bulls. Other systems include combinations of grazing, winter feeding with or without concentrates. The age at slaughter is very important, because enteric CH_4 emissions are a major term for beef and these stop on the day of slaughter. There are also store cattle that link some (sub-) systems. Organic beef is a spring calving sub-set, with longer finishing times and mainly either grass or silage finished. Options that apply to many (sub-) systems include housing type (or not), FYM or slurry, winter forage from maize or grass silage or hay and concentrate level. Soil type and climate will have major influences on winter forage choice and the time spent grazing (important for N_2O emissions).

Previous work with EBLEX by Cranfield University used data from the British Cattle Movement Service and showed that the distribution of ages at slaughter could be closely matched by a set of proportions of production systems already built into the

structural part of the Cranfield Agricultural LCA model. This should offer hope for a better interpretation in the new inventory.

Sheep

The sheep sector is very much related to geography. We propose a simplified structure of the stratified flock with breeding by: hill pure bred flocks, upland (pure and crossbred flocks) and lowland (pure & crossbred flocks). Finishing of hill lambs may be in the uplands or lowlands; with finishing of upland lambs in the uplands or lowlands and lowland lambs in the lowlands. There will also be stores. A major challenge will be to obtain the best estimates of age at slaughter, as with beef. This will be less robust than with cattle, because sheep are not systematically tagged. Some interpretation of the supply of lambs (and ewes) from monthly slaughter returns will probably thus be made.

5.2 Record of Table Discussions

Participants were asked for feedback on the farm systems presented and for recommendations on how they could be improved. The following questions were asked of each group:

1. Are there further within-sector farming systems (or sub-systems) that need to be captured to represent the agricultural sectors adequately?
    a. If so, please specify what these are; and
    b. Give an estimate of what proportion of the total they are; and
    c. Indicate if they are more specific to one part of the UK than another and if so which.
2. Is too much detail suggested? If so, please indicate what is not needed.
3. Does the classification of farm systems adequately capture the full range of production systems?
    a. If not, should we be using different terms of reference to classify systems; and
    b. Please provide examples of better classifications.
4. What sources of data (e.g. especially from industry) can be accessed to ensure that
    a. Differences between farming systems are captured effectively?
    b. Changes over time are captured effectively?

5.2.1 Dairy Group One: Activity One – Farm Systems

In addition to the criteria defined by AC0114, it was felt to be important to capture the following:

- Mixed farming systems, particularly in the east and the north of the UK. Dairy and sheep, dairy and beef, dairy and arable etc;

- Specialist heifer rearing systems;

- Production systems which are designed for the liquid (white water) or processing (cheese) markets; and

- Flying herds – herds that move about the country for specific reasons.

Sources of data for capturing differences and tracking change:

It was highlighted that system tracing on farms can be divided into a number of types, based on the 'data density':

1. Full recording for e.g. for carbon footprinting purposes;

2. Farm recording required for farm assurance schemes. Some farm assurance schemes require farmers to keep very detailed information (e.g. Sainsbury's have detailed information);

3. Farms submitting data as part of milk recording schemes (monthly milk yields/composition);

4. Farms with feed purchase records and/or forage analyses;

5. Simple accounting records: feed and fertiliser purchases, monthly milk cheque; and

6. No records kept at all.

Some information could be collected as proxies for other information, e.g. area of farm land, quantities of fertiliser purchased, costs of purchased feed, but this is complicated on mixed farms. It was suggested that milk yield divided by area of land can give a rough estimate of intensity. Milk companies such as Dairy Crest are in the best position to provide the most accurate information on milk yields. Breed could also be used as a proxy of weight for dairy cattle. Age of the national herd could also be accessed through the British Cattle Movement Service (BCMS) and June Census. However it is important to note that Aphis (Animal and Public Health Information System) rather than British Cattle Movement Service is used for national herd monitoring in Northern Ireland.

For all records, it will be vital to have an estimate of the uncertainty associated with the data collected. A proxy for this level of uncertainty could be the age of the farmer returning the information, on the basis that older farmers are less likely to engage than younger ones. It was also highlighted that the first year's data was very unreliable and should be avoided.

Other, general comments:

Farm education is also critical, although it continues to be difficult to get some (many) farmers engaged. Factors that save the farmer money will be key, although many farmers will continue to operate as they always have.

Getting a handle on local weather conditions is also critical, because these have a big influence on what farmers can do, and how they do it. The Met Office will be the best source of information about this, but there is a large weather/soil type interaction. This influences the numbers of grazing days that cows get.

It was considered important that existing routes of data collection are exploited where possible, to avoid asking farmers for the same information more than once. We would need to be practical about what information we can expect farmers to provide, and how that information is collected.

Key Recommendations offered:

Farming systems:

- Levels of yields approach is ok but need to pick up mixed farming systems, in addition to heifer herds and flying herds;

- Could use a geographical split, based on farms in the South West and Wales more likely to be specialist dairy herds, and those in the East and North East of England and Scotland more likely to be mixed;

Classification of farms:

- Lots of data is available/collected, but need proxies, e.g. Milk yield divided by land area, age of farmer, age of cows, breed (proxy for weight, therefore of intake). BCMS could help with cow breed and age distribution.

Potential data sources include:

- Feed companies and the Agricultural Industries Confederation (AIC)
- Fertiliser companies
- Milk contract management
- British Retailers Consortium; represents the 4 big supermarkets
- Breed societies
- AHDB/DairyCo
- Farm assurance schemes
- Met Office
- Health Records
- Survey of Compound Animal Feed production
- Fertility and health records
- Computerised farm office wall planner data and/or Artificial Insemination (AI) company records
- Feed and manure testing companies

5.2.2. Dairy Group Two: Activity One - Farm Systems

The discussion group did not believe that identifying dairy sector groups simply on the basis of average farm practice statistics for top, middle and lowest tier yields (either total yield or yield per animal) would be satisfactory due to the broad range of systems and overlap in farm practice that would exist between the groups.

This could be improved if the tiers were defined not only by yield but by, for example, volume of milk produced per cow, region or a set number of farms so that the characteristics of each tier were more diverse. Efficiency of production, both economic and GHGs was thought critical to the definition of sub-groups but how do

you define it? Emissions per hectare or emissions per litre? Importance of feed digestibility was also emphasised which can be different between conventional and organic management for instance. Further discussion of the approach taken by Dairy Co to stratifying their survey of Dairy Farm Carbon Footprints suggested that dairy farm systems could be usefully disaggregated on the basis of indices of: a) proportion of forage in diet; b) manure management system; c) upland versus lowland or physical geography, including soil type; and d) replacement rate. There was also question of what level we are trying to disaggregate down to - individual farm or regions or Devolved Administration? It would make sense to start with DA level – and it was suggested that it might be possible to use 'agricultural regions' of the UK.

A question was raised with regard to when dairy GHG emissions transfer to the beef sector. Should it be based on the economic transition? What level of attribution should there be between animal and region? We need to maximise what data is already recorded and available. A specific recommendation was to survey manure management systems in detail for the dairy sector. A concern was raised concerning the self selection bias in the existing industry datasets, but the industry representatives in the group were confident that the spread of data in the available statistics was genuinely representative of the range of farm systems and production efficiencies in the UK and therefore worth further analysis. In terms of data supermarket pools were identified as a potentially useful source. A question was also raised with regard to the fact that dairy farming systems could change substantially over the next few years – how will this be represented?

Key recommendations offered:

Distribution of three levels needs to be expanded further to include the following factors:

- Replacement rate
- Percentage of milk from grass
- Manure/slurry management

5.2.3 Beef and Sheep Group One: Activity One - Farm Systems

The discussion focussed on beef systems only.

The discussion group felt that in Northern Ireland and Scotland there would be very few animals finished under 15-16 months, due to predominance of grass-based feeding. It was suggested that better division for the lower age categories would be 11-14 months and then 15-17 months. A 24 month+ band was also suggested. It was also suggested to look at whether a farm is mixed (e.g. growing own cereals) and the impact of this on finishing.

It was highlighted that for Northern Ireland, suckler herds are mainly extensive in upland and lowland areas. For Scotland, the group were not sure if the data was available on the finishing ages for the different feeding regimes. It was highlighted that this varies greatly across Scotland (especially from East to West) and feeding regimes can change from one farm to another.

It was also suggested that it could be useful to look at housing period/grazing period, but that this can be incredibly variable year on year. There has also been a move towards using sacrifice fields to out-winter stock and in Northern Ireland there has been nine-month housing in some areas in the last few years due to weather

conditions, a similar situation to the west coast of Scotland. Also details of types of housing could be collected – e.g. slats versus straw – giving additional information on FYM or slurry.

Useful data would also be carcass weights, in relation to age at slaughter, fat score at slaughter, dead weight and calving interval. Some of this information could be accessed from the BCMS.

Ration composition would also be useful, in terms of forage (i.e. conserved or grazed), dry feeds, compounds and co-products. With regard to organic/non-organic systems there was a question of whether there is really a significant difference between the systems, i.e. do the definitions need to be split? It was suggested that we do not know yet whether there is a difference between the systems, so we need to split up the definitions to see where the differences lie. It was also suggested that data on out-wintering be collected (giving information on feed of brassicas/grass).

Further clarification was required on what was meant by 'Spring Calving' and 'Autumn Calving'. The suggestion from the group would be that 'Spring' could be Jan-June and 'Autumn' July-Dec.

It was also suggested that calving intervals be collected as a measure of reproductive efficiency of breeding stock.

Sources of data for capturing differences and tracking change:

Northern Ireland has a central database and can trace every cow through from birth to wherever it goes (i.e. APHIS - Animal and Public Health Information System). This system can also show whether the calf has a dairy dam or a beef dam. For England, it was highlighted that it wouldn't be possible to know if the animal is associated with a hill or lowland herd. It would be possible to know the holding with which the animal is associated but that might not give the system.

A Phenotypic database called the Bovine Information System (BovIS) has also been developed in Northern Ireland. This has integrated APHIS and meat plant data and has enabled the effect of dam and sire breed, gender and growth rate and their interactions to be analysed. Plans are in place to produce outputs from the database which can be used to inform all tiers of the industry Information will be available on dam and sire breed, gender, age, carcass weight and their interactions on growth and carcass characteristics. This information can be used to identify breeding and management strategies to meet a range of market specifications with the maximum possible production efficiency. At producer level, key benchmarking data can be generated relating to reproductive performance of beef cows, and the growth and carcass quality of cattle. In addition, information from this database can be used to determine the genetic merit of individual animals and thus underpin future genetic improvement programmes. Very large amounts of data have already been collated and this work has shown that the data are robust and able to provide important information for the industry to develop breeding and management systems to meet market requirements. Future developments will enable outputs to be directed at individual farm level

For Scotland, it was suggested that it may be possible to interrogate the IACS (Integrated Administration and Control System) database through the Scottish Government, for farm types e.g. permanent grass vs mixed with some arable. Alternatively the June Census could be used at a regional level and then say which systems are typical of that region.

Farm assurance schemes might have some data e.g. on farm systems and length of housing. Other sources of data include the Farm Practice Survey, which has data on farm yard manure, slurry etc, Quality Meat Scotland (QMS) also has data on cattle and sheep profitability in Scotland. EBLEX also has costings/expenditure on feed and N fertiliser use as part of the annual 'Business Pointers' document.

Other general comments:

It would help to have standardised questions for national surveys throughout the UK (e.g. FBS/FPS). Also, surveys tend to be filled in by people who are good at what they're doing and want to show it so need to bear in mind the potential bias.

Key recommendations offered:

- Enhancing FBS data collection to include details of housing period and housing type (e.g. deep litter, slurry/slatted floor, out-wintered);

- Re-categorise finishing age bands for cattle to as follows:
    - 11-14 months
    - 15-17 months
    - 18-20 months
    - 21-24 months
    - 24 months+

- Try to capture efficiencies in an improved inventory as functions of calving interval and carcass weight to age at slaughter.

5.2.4 Beef and Sheep Group Two: Activity One - Farm Systems

The discussion started by considering the proposed 'finishing categories' of the beef production systems. It was agreed that there should be additional categories of 25 – 29 months and 30+ months. This was felt to be important for Wales, Scotland and N. Ireland where there was more reliance on grass than on concentrate feed. It was pointed out that a lot of bulls would be in the 13-16 month category and that slaughter age bands should be continuous. The group felt that it was important to record and track transfer age from suckler herd to finishing (e.g. 3 months or 7 months), sex of animal and the proportion of forage in the diet. A greater reliance on legumes in the sward would lower synthetic fertiliser use and hence lower GHG emissions. It would be useful if rations could be disaggregated into proportion of grass, silage and concentrates (analysis of concentrates important). Information on cereal input and N fertiliser input is available from FBS. A record of days grazing would indicate whether beef were permanently housed, part-year housed or out-wintering (slurry vs manure). Feedlot systems would increase NH_3 emissions and impact on the NH_3 inventory, so some suggested combining the GHG and NH_3 inventories. Although the organic beef sector was currently only 1-2%, it needs to be future proofed and on a regional basis it may be important e.g. Wales. As many beef systems calve all year round, some felt that the definitions of autumn and spring calving should be loose (in England). However, it was felt by others (e.g. Scotland) that these definitions should be distinct.

Recording of grassland management (including legume use) could be improved, for example considering rough grazing (where animal is on a maintenance ration

producing methane but not necessarily adding to production), permanent grass and grazing strategies (use of conacre land [short term let]). It was accepted that this would add to the complexity of the farm system. However, the general consensus was to have representative scenarios to capture key variables that would have an impact on GHGs and create more manageable systems. Although soil maps are available to show the location of organic (carbon rich, rather than organically-managed) soils, accessibility of sites is an issue, especially in Scotland, where many soils never receive N fertiliser

Age at transfer was also highlighted as being an important factor, and it was highlighted that we need to pick up on the issue of out-wintering or part-year housing versus permanent housing. With regard to autumn versus spring calving, it was suggested to keep the definitions loose for England, but more distinct for Scotland. It would also be helpful to distinguish between slurry and deep-litter manure based systems.

The issue of N_2O emissions from organic soils was also highlighted as being important area to pick up on, especially for Scotland. With regard to sheep it was felt as important to define 'lower' and 'higher' weight ranges, mutton production could also be given a separate category.

It was also considered as being useful to capture grassland management types, including grazing strategies, and trying to associate nitrous oxide emissions with these. Age of slaughter was also picked up on in this group as being an important indicator for determining methane emissions.

Hill cross bred sheep was felt to be an important addition to the sheep production systems, which has lead to increased carcass weight in N. Ireland and Wales. There needs to be better definition of 'lower' and 'higher' weight ranges. For example, is the lower weight range of hill sheep the same as lower weight range for lowland sheep? There was also discussion about litter size, mutton production and organic systems.

In summary, the three recommendations, from the group, as to how farm systems definitions could be improved related to:

1. Age and weight at slaughter
2. Need for representative scenarios to represent industry and capture GHG impacts
3. Grassland management

5.2.5 Arable and Horticulture Group: Activity One - Farm Systems

Discussion revolved at first around the types and value of available data to characterise arable and horticultural practices. The June census and survey of fertiliser practice (BSFP) were cited and questions were raised about whether better surveys might be possible.

The structure of the potential inventory was discussed and Tier 2 and Tier 3 inventories explained. The questions then focussed on what would be needed to be measured in order to obtain more specific emission factors for crop and soil and crop residues. There was much discussion on whether farm type is the best classifier and it might be better to classify by activity or by crop/cultivation, e.g. mono-culture, rotation, organic rotation.

A concern was expressed that the inventory may be driven by the data that is available, rather than through collecting the right data.

Farm business and farm practice surveys were suggested as useful sources of data An LCA approach was also suggested as useful although Tom Misselbrook explained the differences between the specific GHG inventories that we are trying to compile and the wider LCA approach

There was some discussion about the DNDC model of nitrous oxide emissions and if we were committed to this (not exclusively is the answer). The Defra funded MinNO project will be assessing the use of DNDC.

Some organic mixed farming undersown systems were thought not to be captured in the inventory proposals. The legume phase may build up N and thus the risk of N_2O emission. Non-cropped land is also not well captured in the inventory or in the June census: nor are field margins.

HLS schemes were thought to occupy a relatively small area. These might affect the inventory on a per ha basis but not on a per tonne basis. Suggestion was to split into cropped, uncropped and non-cropped areas

Defra have records of permanent pasture because ploughing of grass more than 5 years old requires permission since 2002. Farm assurance data could be useful. Organic farmers have to collect much data for certification which could be useful. SRC and miscanthus might differ in allocation by sector. There were reservations about whether SRC was forestry or not

Variation by soil type and climate was felt crucial for the inventory. There was felt to be a need to understand efficiencies. It was not clear if input-output data was sufficient in this case. Sugar beet had improved greatly in its efficiency in recent years and there was a question of whether this could be represented.

In summary, the three recommendations, from the group, as to how the arable and horticultural farm systems definitions could be improved related to:

1. It may be better to explore the potential for the Inventory to use crop type rather than farm system as a basis for reporting. However there was not a consensus on this within the group;

2. Need to consider a different approach in terms of the use of data - it may be better to set the optimum level of data that we require and then change the surveys to collect that, rather than relying on the current data that is collected/available; and

3. There may be some spatial correlation between cropping and soil and climate that the project team could take into account, to help simplify the systems descriptions, but this is unlikely.

5.2.6 Pigs and Poultry Group: Activity One – Farm Systems

Poultry

Layers: Caged (conventional) category will disappear completely as of the end of 2011, as a result of compliance with EU Welfare Regulations. The old cages

(550cm^2/bird) to be substantially replaced by "enriched" cages (750cm^2/bird), though not entirely – as a result, some reduction in bird numbers expected and it was suggested may result in egg shortages. It was noted that there were no derogations across the 27 MSs, so reducing concerns about cheap imports from across EU (but what about from outside EU?).

Belt removal of manure was now commonplace, though "with drying" on the belts was relatively rare – it was noted that the plastic ducting to facilitate drying (relatively cheap) was often installed, though the fans & ancillary equipment (much more expensive) was rarely installed. Hence, a suggestion to remove "with manure drying", but also view expressed that this option be retained to allow for future implementation of mitigation measures? In practice, belt removal is normally undertaken *ca.* every 2 days, which greatly reduced emissions (NH_3), so is additional drying of questionable benefit?

Still a few "stilt house" units (like deep pit without walls), now with enriched cages.

Free range – suggested ca. 54% free range production (total UK layers *ca.* 60m birds), though most in units of <36,000 birds. Some confusion about meaning of "rotational" housing – does this apply to mobile sheds (with earth floors), which are moved periodically to allow manure spreading? Larger sheds have concrete floors, with manure collecting below slats. Some Free Range and Barn systems include multi-tiered cages with manure belts discharging to trailers (weekly removal).

Organic production felt to be <5% (possibly only 2-3%) so combining these with "free range" category may allow a simplification for data collection (not agreed by all)?

Agreed that associated pullet rearing (litter based) should be included for all categories; also broiler breeders (layers).

Broilers: (ca. 330 million birds?) – data available from BPC? Emissions (NH_3) from broilers noted to be strongly impacted by cropping cycle, with max emissions occurring beyond 35-36 days (cycle commonly 42 days). Note – does UKAEI currently take this into account? Note – EA said to have a requirement for litter testing (monthly) (target for 45-65% DM).

Turkeys: Some confusion about meaning of "pole barn" category – are these "Dutch barns" with straw litter (small producers only)? [Yes is the answer - AGW].

Ducks: Not included in the AW farm systems categories. Although relatively few and concentrated across a few large producers, because of the production system and manure characteristics (wet - low DM, low uric acid, low NH_4-N content), thought to be significant potential emission sources, so should be considered for inclusion?

Data sources

Perhaps extra questions could be included in the Defra poultry register?
BPC/BEIC data/records to be explored?

Pigs

Housing systems
Noted that the proposed categories mixed ventilation systems and manure management systems – thus natural ventilation and fan ventilation could occur

across solid floors, fully slatted floors and part-slatted floors (currently lumped together as alternative categories a, b, c, d, e) and across all stock types – sows, growers and finishers. There are also solid floor systems with scraped passageways which can generate either solid manures (drier with some litter addition) or slurry (with little/no litter).

Sows
The need to differentiate between dry and lactating sows was raised (because of their very different diet and management). Also, some farmers keep the dry sows indoors in straw yards, then move them outdoors to farrow. At the moment these get the outdoor badge, but that is going to change. However, opinions differed – currently in NVZ rules only "sows" identified, this being thought to be simpler and less likely to cause confusion (having both could give rise to double counting?). Note – breeding gilts are a significant category with different diet and excretal output and probably more important to include rather than dry vs lactating sows?

Outdoor production
Note – should be referred to as outdoor sows rather than "free range". Currently estimated to be ca. 40% breeding sows kept in paddocks with accommodation in arcs, tents or kennels. Encouraged by EU Welfare rules – but it had been estimated that outdoor production was associated with 25% increase in carbon footprint? Stocking density varies considerably and could be significant in terms of emissions.

Growers and finishers
The current anomalies between IPPC and NVZ categories (LW classifications for growing pigs) should be reconciled. Finishing wt categories: Pork, Cutter and Bacon – to some extent these categories becoming less relevant in view of trend towards a "processing" pig of 70 - 80kg LW going to pork or bacon. Finishing weights are climbing slightly.

Data sources
EML (electronic movement licences) for pigs (are these via BPEX or Defra??)
Some information available for IPPC permitted units (but covers relatively small proportion of pig units)?

EPR Pollution Inventory is already used by IPPC farmers. http://www.environment-agency.gov.uk/business/topics/pollution/32296.aspx and could be a useful source of information. NVZ record keeping is also in place on a lot of pig farms.

Farm management software offers a potentially useful source of data, for all farm systems, and software houses can adapt their programmes so that things like NVZ and tax calculations can be produced quickly. There may be potential to discuss with them how they could produce data quickly and painlessly. As farmers become more IT literate, this would be a logical way to go. Inputs and outputs are all recorded so it should be relatively straightforward.

Farmers also have to keep records for taxation purposes, so again input/outputs are recorded at a financial level and could be used.

Other General Comments

The biggest changes going on are in feed nutrition, reducing protein especially through use of synthetic amino acids.

Emission Factors are very questionable because those used in EA Annex 1 are not qualified in any way, pus there is a big range of uncertainty associated with measurements in any case.

6. Presentation and Discussion of Mitigation Methods

6.1 Presentations

6.1.1 Tom Misselbrook (Rothamsted Research – North Wyke) Accounting for Mitigation Practices in the Agricultural Greenhouse Gas Inventory

Tom Misselbrook presented on how an improved agricultural GHG Inventory could potentially capture mitigation of GHG through changes in farm practices as detailed in the various industry Action Plans and Road Maps.

The agricultural inventory could only reflect mitigation practices relating to nitrous oxide or methane emissions and within the boundary of the 'farm gate' (i.e. not reflecting embedded or downstream emissions). Mitigations related to energy use and or land carbon storage would be picked up within other sectors of the national inventory (Energy and Land Use, Land Use Change and Forestry, respectively). While this project has a specific focus, the importance of representing the wider view of mitigation within the agricultural sector was acknowledged.

Mitigations (within livestock and cropping) could be broadly categorised as those which improved efficiency of production, thereby resulting in more productive output per unit of GHG emission (e.g. improved nutrient planning for crops, improved health of livestock), and actions targeted to directly reduce emission from a specific source (e.g. a feed additive to reduce enteric methane emissions, nitrification inhibitors used with fertiliser applications). A revised inventory methodology must therefore include relevant management practices (fertiliser application rates and timings, manure management practices, livestock diet characterisation, etc.) within the defined farm system typologies and report emissions per unit product, so that efficiency gains can be reflected in addition to changes in emission due to increased or decreased production. Mitigation practices specific to a particular source (such as feed additives and enteric fermentation) will be associated with an evidence-based reduction to the standard calculated emission factor for that source and a factor for the level of implementation within the sector. General efficiency measures may not always be associated with a specific management practice or have a defined reduction factor within the revised inventory structure, but will be reflected through changes in key activity data, such as less overall fertiliser N use or fewer dairy replacements, which again can be presented as a function of total product output.

The mitigation measures described in the various Action Plans and Road Maps have been documented and an assessment made of which of those fall outside the scope of the Agricultural inventory (but may be relevant to the Energy and LULUCF inventory), and how the remaining measures will be reflected in the revised inventory structure. It is important that there is some anticipation of potential mitigation measures not yet identified within the action plans, but which may become important in future years.

6.1.2 Amanda Thomson (Centre for Ecology and Hydrology – Edinburgh) The Land Use, Land Use Change and Forestry (LULUCF) sector in the greenhouse gas inventory

Amanda Thomson presented an overview of the Land Use, Land Use Change and Forestry (LULUCF) sector in the greenhouse gas inventory highlighting that this

sector reports carbon stock changes and GHG emissions from specific land management activities.

The sector is reported at a Devolved Administration level, with the results being summed to give a total figure for the UK. The reporting is based on six land use categories, defined by the IPCC. These are forest land; cropland; grassland; wetlands;, settlements; and an 'other' category. Reporting is also divided into categories according to land remaining the same (e.g. grassland remaining grassland) and land converted between categories (e.g. grassland to forestry) in the period between annual reports.

The significance of the sector with regard to Kyoto Protocol reporting was outlined. The accumulation of carbon credits from forest land management can count towards target reductions within the 2008 - 2012 commitment period of the Protocol. Under article 3.3, of the Kyoto Protocol, the LULUCF sector must also report new forest planting and deforestation, since 1990, and voluntarily reports forest management for woodland established pre-1990 under article 3.4 of the Protocol.

It was highlighted that the LULUCF section of the inventory covers carbon stock changes for three main land categories: living biomass (gains and losses); dead organic matter (net change); and soils (net change in mineral and organic soils). It was also highlighted that N_2O emissions from nitrogen fertilisation of forest land is included within LULUCF, and that the sector could also report nitrous oxide and methane emissions from drainage of forest land and wetland, if they could find sufficient data. Nitrous oxide emissions resulting from land disturbance, associated with a conversion to cropland is also reported in the LULUCF sector, as are CO_2 emissions from liming. Methane, nitrous oxide and CO_2 emissions from biomass burning are also included. Emissions/losses from wildfires for grassland could also be included, if there were sufficient data to allow for this.

A graph was presented showing that LULUCF Inventory reported a net source of emissions in 1990, and has moved to being a net sink in 2009. The headline net emissions hide large differences between the different land use categories. An explanation of land category definitions, which are taken from the IPCC guidelines, was then given

Data sources used within the sector were then described. The CEH Countryside Survey is currently used to provide detail of land use changes over time, which can be used with soil carbon models, This survey does not include Northern Ireland but the Northern Ireland Environment Agency undertake a similar survey in Northern Ireland. Forestry Commission data is also used to obtain details for forest expansion and estimates of woodland conversion to farmland and development. The June Agricultural survey is also used, but there have been issues with this survey, the Countryside Surveyand the Forestry Commission data, in terms of tying up the different categories/definitions of land. The British Survey of Fertiliser Practice has been used for data on lime application rates, in addition to mineral extraction statistics for amount of lime used for agriculture. With regard to emission factors, the LULUCF sector currently uses soil carbon databases, forest growth models, and default emission factors from the IPCC.

A short introduction was given to the future plans for an AFOLU sector (Agriculture, Forestry and Other Land Use). This will seek to combine the greenhouse gas reporting and carbon stock changes for the agricultural and LULUCF sectors, in a

coherent way. However this will not happen until we finish the first Kyoto protocol commitment period, and so will not be implemented until 2014/15 at the earliest.

The mitigation potential captured within the LULUCF section of the inventory was also mentioned, with particular regard to land use management and soil carbon management. A Defra funded study is currently looking at the potential for mitigation from land management, in addition to a pilot study using Integrated Administration and Control System (IACS) data in Scotland. The fact that mitigation options within the LULUCF inventory are longer term options was highlighted – there is less capacity for 'quick wins' that will show an immediate improvement. Some of the issues are with regard to permanence; for example you might have very slow gains in soil carbon, but it is possible to lose these very quickly, e.g. you may be accumulating soil carbon over five years, through reduced tillage, however if you then plough in year five you will be losing the gains very quickly.

It was stated that there is a challenge to policy makers, in order to get the necessary activity data on what is happening to inventory compilers, and in terms of monitoring compliance. It was also highlighted that the science in this area is still developing, and there is a need to consider the whole greenhouse gas balance. For example there is quite a lot of interest in wetland restoration, however one of things that research in this area is revealing, is that time period is quite important, so you might get savings of carbon dioxide, but in the short term that might be offset by losses of methane, so you cannot consider one gas, such as CO_2, on its own. There was also discussion at the Climate Convention talks recently as to whether they could bring wetland restoration into the second commitment period of the Kyoto protocol as part of reporting 'avoided emissions' within the LULUCF section of the inventory. Finally, the importance of capturing cross-sectoral impacts was highlighted. These might result from developments in such areas as renewable energy generation, e.g. the expansion of wind farms in the UK, to reduce CO_2 emissions from energy generation, may result in carbon losses through deforestation.

6.2 Record of Table Discussions on mitigation methods

Discussion groups were asked to recommend three specific mitigation methods for explicit representation in the improved Inventory methodology.

6.2.1 Dairy Group One: Activity Two – Mitigation Methods

Five major groups of mitigation options were identified:

1. *Dietary manipulation*

These included options such as increasing the amount of whole-crop cereals (maize, wheat etc) in the diet to reduce methane and nitrogen emissions. A proxy for this would be forage maize seed sales, but this indicates areas grown, and not necessarily used for feeding to dairy cows. Monitoring of milk yield, divided by number of cows could help measure improvements of efficiency in this area. Sales of dietary supplements, additives and concentrates could also be useful as could feed analysis to help assess feed quality (which will directly influence methane emissions). An improved bull merit index would also be useful and it was suggested that a methane index could be used to improve classification of sires with regard to greenhouse gases.

Reducing the amount of N in the diet would reduce the amounts of N excreted. Feed company records of e.g. the amounts of 16% Crude Protein versus 18% Crude Protein compound feeds sold might be useful, but this excludes home grown and mixed feeds.

Improving the understanding of feed characteristics is important, in terms of knowing what the methane production potential is. Feed testing companies may offer information on average values of silages tested each year to provide information on likely efficiency of use in a year.

Options such as feed additives that reduce methane emissions could be tracked through company sales, and the re-introduction of feed additives such as ionophores could be considered (although rumen population modifiers often have a relatively short-lived effect).

It is important that we take account of trade off effects. Use of whole crop cereals and/or maize in ruminant diets might reduce methane emissions but will increase N2O emissions from soil (if grassland is ploughed up to grow maize and wheat) and may also release C locked up in permanent grassland.

2. *Grassland management*

This offers much potential to mitigate GHG emissions from animals at grazing, and included soil management as well as sward management. Seed sales of e.g. high sugar grasses, grass/clover mixes etc. could offer proxies for changes in management practices.

Details of reseeding could also potentially be accessed through the Farm Practice Survey. Sales of chain harrows could also provide a proxy in this area. Worm survey data / bird surveys could also help to monitor grassland condition.

3. *Manure management*

As for feed management, there are lots of mitigation options, ranging from precise testing of manures to get information on the N value (a proxy for this could be the numbers of kits sold for home-tested manure, number of manure covers sold, and company records for lab testing), to technological advances in spreading (proxies included sales of injection or band spreaders) and storage (manure heap/slurry tower cover sales).

Anaerobic digestion was considered as an option, although methane yield from slurry alone is relatively poor – 85% of the methane is lost enterically before the manure is digested. Co-digestion is an option, but farmers need to be encouraged to grow crops to feed animals, rather than remove the animals from the system to feed the digesters directly (as is happening in Germany).

4. *Herd health and fertility*

The ‘big three’ of mastitis, lameness and fertility are still a common problem for dairy farmers, and lead to reduced efficiencies. Other diseases such as TB also lead to inefficiencies and new ways of dealing with these could be considered. Number of tubes sold and number of foot trimmings/foot baths could be used as a proxy for mastitis levels and lameness respectively. Fertility indices would also be useful.

5. Genetic improvement

Breeding animals for improved health and fertility, increasing animal longevity, was considered a constant long-term goal. However, there is therefore a constant need to consider the G×N interactions – how do we best feed modern dairy cows for optimal efficiency?

Breeding objectives could include new indices such as methane emission potential of bulls, and residual feed intake, although the long term consequences for some of these characteristics are still not fully understood.

6.2.2 Dairy Group Two: Activity Two – Mitigation Methods

Three groups of mitigation options were identified:

1. Anaerobic Digestion

Initial discussion concerned technical innovation and specifically the adoption of anaerobic digestion. The industry representatives in the group were confident that AD has a significant future in the dairy sector as the technology matures and costs of installation are reduced. The potential for community digesters and feeding gas directly into the gas pipeline network rather than electricity were identified as opportunities for simplifying the infrastructure required on-farm. However, the intensive management and staff time and training costs required for AD were a barrier to adoption. Less intensive mitigation would be carbon sequestration – planting small woodlands/orchards.

2. Improved Health and Fertility

A second tier of mitigation concerned improved health, longevity and fertility dairy cattle. In particular, tackling animal diseases such as TB was critical. The use of single sex semen to reduce the waste of males calves and persuading the integrated supply chains to accept dairy bred beef and dual purpose breeds were seen as having potential for reducing wastage. As an aside, the oft quoted 30% food wastage by UK households was discussed and it was suggested that the figure for dairy products was only 10%. Use of dairy beef animals by the supermarkets could also help mitigate greenhouse gases – ASDA currently has a policy in place for 'Low Carbon Beef' but some other retailers have dropped this due to increasing grain prices

3. Improved Feed Formulation

A third tier of mitigation was improved feed formulation to reduce excess protein in the diet, and potentially increasing the energy intensity of diets. For example through feed additives such as fats, and through a maize based diet, although this would be geographically limited to the south of the UK. A difficulty was highlighted in terms of establishing a baseline survey of feeding practice. However, the dairy sector is characterised by intensive record keeping, and providing some fair exchange of information can be agreed, it may be possible to access industry data on feed formulations from private companies such as Kingshay and Promar milk recording. A repeat of the DairyCo 400 Farm Carbon Footprints in future would provide a measure of change. Improving the FBS and FPS would help with this. Feed compounders also have national usage statistics and individual business data is available on a farm level, but there might be verification costs.

It was also highlighted that with intensive units the slurry may be going off farm so emissions will be different – which part of the inventory does this fit in? A question was also raised as to whether we can give anything back, to reward farmers reducing their emissions.

6.2.3 Beef and Sheep Group One: Activity Two – Mitigation Methods

Three recommendations were made for inclusion and/or measurement in the Inventory methodology:

1. Grazing Efficiency

Improving the efficiency of grazing at grass, including such measures as measuring clover content and use of high sugar grasses through sales of seed. Also, improving the performance of the livestock off grass (genetics).

2. Increased Growth Rate

Reducing days to slaughter, this is easily tracked for beef, but is much harder for sheep as they are not registered from birth. Also, including tracking health problems (e.g. liver fluke, Bovine TB, BVD levels.

3. Production Efficiency

Improvements to and measurement of efficiency, for example with regard to fertility (e.g. number of lambs and calving intervals) and kg output of produce from the breeding herd. Looking at areas such as age at first calving, reappearance back into the herd as a calving cow (particularly used in Northern Ireland).

There was further general discussion as to whether a measure should be put forward for inclusion if it is hard to track. It was suggested that improvements in production efficiency would be picked up through the inventory anyway, for example in New Zealand the number of breeding ewes has decreased but kilos of lamb produced has increased. This is being recorded through the livestock numbers included in the improved Greenhouse Gas Inventory in New Zealand.

The importance of measuring inputs was also highlighted – output is not a measure of efficiency if you aren't also measuring what the inputs are. We are also assuming shorter time to slaughter reduces inputs but this could require more cereal to get to slaughter weight. However it was highlighted that there is a question as to whether the animal would eat the same MJ of energy over their lifetime anyway, moreover, as we are looking at emissions, if the animal is slaughtered sooner then you lose those extra days of emissions.

For sheep the percentage of lambs weaned is the measure preferred for measuring efficiency. Number of lambs slaughtered per ewe flock can be accessed from slaughterhouse records. However a complication may be caused by the fact that 70% of NI lambs are exported out of the country live. The best measure for sheep may be slaughter numbers and weight. We cannot tell finishing times from slaughter dates – if selling early could have lambed early.

On sources of data, there may be ad-hoc industry surveys which may tell you lambing dates but usually farmers are too busy then to keep records in detail. QMS (Quality Meat Scotland) is encouraging the recording of performance.

There was also a comment from Scotland that LULUCF is not recording permanent pasture converted to heathland and that is a big gap in the figures.

There is a difficulty in allocating inputs to this sector. It is possible to use the amount of grassland used divided by number of animals (very generic) but would need to remove horses, goats etc. There were also concerns expressed about how the final data from the project could be used and could result in “ruminant bashing”.

6.2.4. Beef and Sheep Group Two: Activity Two – Mitigation Methods

The main mitigation strategies identified for inclusion in the Inventory were:

1. *Improving Animal Health and Welfare*

The group agreed that there was a need to reduce endemic and infectious diseases (e.g. Johne’s, liver-flukes etc.), as less animal replacements would lead to less GHG emissions. Improving fertility (reducing calving interval) and mortality rates were also important issues.

2. *Improving Animal Nutrition*

The role of balanced nutrition was discussed and the importance of macro and micro elements. Nutritional analysis of feed should match rationing model to lowest GHG emissions. Clover and high sugar grasses were seen to have potential in the diet. Protein contents of diets could be reduced if there was a move to more grass based systems, which would have the added benefit of increasing soil C.

3. *Improve Genetic Potential*

Estimated breeding values (EBVs) to record genetic potential was discussed, however it does not necessarily improve breeding value. Target should be to increase growth rates and livestock productivity through genetic improvements. There should be better use of the 5th quarter (e.g. offal etc.) to reduce carcass waste. There was considerable discussion as to the best way of expressing livestock productivity. Should it be kg/unit input (feed and fertiliser input) or kg product/ha? There seemed to be merits of both depending on system context.

4. *Improving N Use Efficiency*

Discussion centred around the efficient use of on farm resources (manure and fertiliser) and covered timing and application method of manures (low trajectory spreading techniques to reduce NH_3 emissions), valuing manure for its P and K content, potential benefits of N inhibitors, improving N budgets and use of AD. The increased use of AD not only has large cost implications but may lead to unintended consequences, for example, if the area of maize is increased to supplement anaerobic digesters (as has happened in Germany). AD also requires high manpower and plant malfunction can lead to high methane leakage. The potential for unintended consequences in other areas also needs to be borne in mind e.g. high productivity may lead to increased fertiliser N use. The importance of soil and herbage analysis was mentioned as N will not be used efficiently if other nutrients e.g. P, K & S are sub-optimal.

A key measure was highlighted as being the management of manures and slurries. Including the timing and method of application. Use of nitrification inhibitors was also

suggested as an important measure to capture and low methane emitting livestock breeds. AD was suggested as a possible method but there are still considerable risks associated with plant malfunction and methane leakage. Looking at the GHGs per kg or per ha produced was also raised as a key question – which unit do we choose for comparing systems?

6.2.5 Arable and Horticulture Group: Activity Two – Mitigation Methods

Separate research from uptake of best practice. Mitigation may be a moving target if best practice is changing. Crop improvement through genetics/breeding should also be captured.

We need to address sources of error: activity data and emission factors make up the inventory - we don't want more error in one than the other. Inventories may be rather sensitive to activity data.

The BSFP has data from 1500 farmers and should be quite robust for rates and timings of applications. RB209 could be used for splits. There are reports to Defra as to whether guidance has been used, which could be useful.

Differences between straw that goes back on land and straw that is removed for bedding and burning need to be clarified.

Factors other than N drive N use efficiency, crop protection other nutrients, water
What effect is compaction having on N_2O and impeded drainage and both together?

Training an advisory service fully was thought a useful mitigation measure
The use of nitrification and urease inhibitors for use on land but also in manures and slurries was discussed, biochar was briefly mentioned.

Precision farming was suggested to increase. The form of N applied were discussed and the benefit of linking the NH_3 and N_2O inventories. The suggestion was made that industry (chiefly) millers might be able to adapt to lower levels of protein in grain thus reducing the need to apply large amounts of N.

Key recommendations were for the inclusion of the following:

1. *Monitoring Uptake of Best Practice*

   Monitoring of uptake of best practice: one way to achieve this would be to use a small sample of farmers to provide very detailed information on these sectors. However a question was raised as to whether these farms would be 'typical'.

2. *Optimum Nutrient Use and Crop Protection*

   Optimum nutrient use and crop protection (including other things than only N) was also suggested. This could be measured by looking at N use per unit of output, for example from NFU yield data.

   3. Improved Variety Breeding

Improved variety breeding for N efficiency was also suggested as a potential method. Data from the British Society of Plant Breeders could help to achieve an estimate of uptake of key varieties, HGCA also have data that could help with this.

4. Improved Soil Management

Improving soil management, to reduce compaction and related N_2O emissions was also recommended, as was the use of nitrification inhibitors

6.2.6 Pig and Poultry Group: Activity Two – Mitigation Methods

Discussion identified common themes across both pig and poultry sectors and sub-sectors:

1. Feed Efficiencies

Feed efficiencies (FCR), growth rates and productivity important. The "Two tonne sow" had been identified as an indicator of production efficiency in the pig industry – i.e. 2 tonnes of pig meat sold via the progeny of an individual sow per year, an indicator of efficient production. An equivalent in the poultry (layer) industry would be a 365 egg per year layer.

2. Novel Feeds and Technology

Novel feeds and technology – controlled diets for both pigs and poultry via low N feeds, involving use of essential synthetic amino acids (note "green pig project" involving range of diets). Interest in alternative feeds (including maize silage) for pigs. Lifting the ban on processed animal protein would help improve N utilisation overall. Likely to be development of novel proteins (e.g. algae) in response to increasing vegetable protein (mainly soybean meal) prices. Continued development of feed additives (mainly enzymes) to improve feed utilisation is expected, although high cost of obtaining authorisation will limit this to only the largest pharmaceutical and enzyme manufacturing companies.

3. Improved Health and Longevity

Improved health and longevity important; increased number of parities (from 5 up to 7) per sow. For hens, up to 60 week production cycle?

4. Market specification

Identifying and meeting market spec of crucial importance to utilisation. Also improved utilisation through promoting and selling more of carcass, e.g. pig ears, oil extraction from hind gut (?), chicken feet.

5. Manure Management and Processing

AD (growing maize is out) not good for poultry manures; co-digestion with other feedstocks or residues possible but adds complication of waste licensing permit requirements? Centralised digesters offer good potential in right locations. Otherwise small (simple) farm digesters (c.f. in SE Asia – but de-sludging has caused problems in those countries?)

Some litter manure burnt (estimated at 80% of broiler litter in Scotland) for power generation. Ash contains high content of phosphate and potash (e.g. “Fibrophos”) but N is lost – mostly as N_2 with an efficient burner. But questions concerning the overall efficiency (full LCA needed) – although N loss may not represent an emission, to replace the N content in the production system (feed to manure N) will require energy input!

Manure drying (poultry) can make a positive impact – reducing costs of carting and spreading. May increase NH_3 emissions, but rapid (in-house) drying reduces emissions and leads to a stabilised product in storage. Some research has also indicated reduced emissions (and increased N utilisation efficiency) from spread manure, so a potential “win-win” scenario.

General note: *it is important to recognise that emissions of NH_3 (gaseous emission) and NO_3 (leaching) represent indirect sources of N_2O emissions and should be minimised for this reason as well as their direct environmental and economic impacts.*

Data sources
IPPC permitted units – diet strictly controlled within permits (but covers relatively small proportion of pig units)?
Survey approaches unlikely to be available or useful for much of these data. A lot of data is currently recorded by industry, e.g. farm records. Secondary indicators could also be useful.

7. Summary and Conclusion to Workshop

Laurence Smith thanks the delegates for their contributions, and the invited speakers from industry and the Devolved Administrations.

The discussions identified a number of important refinements to the candidate farm system models. For example, further refinement of the pig and poultry systems descriptions to reflect recent changes in regulation and farm practice are required. Further refinement is also required for the ages at which beef cattle are slaughtered, and clarification of some terms used in the descriptions such as ‘high’ and ‘low’ slaughter weights. These specific refinements will be acted upon.

A number of important common themes from the table discussions were also identified and require further exploration by the AC0114 delivery team. These included:

- Consideration of whether the Inventory is better planned around the availability of existing data sets as opposed to planning to use future data sets from new and revised surveys. Planning on the basis of future data sets involves some risk as cut backs in government and industry may limit future data collection.

- Consideration of the intellectual property rights and confidentiality associated in particular with industry data sources. Appropriate procedures need to be put in place to protect the existing data sources. This needs to be balanced against the resource-efficient exploitation of existing industry routes of data acquisition as opposed to organising new public domain surveys in order to overcome obstacles, such as property rights and confidentiality.

- Consideration of fewer indices to disaggregate a sector into a simplified set of farm systems that reflect the key drivers for change in emissions, rather than a comprehensive disaggregation into all types of farm system that exist today. For example, the dairy sector might be usefully disaggregated on the basis of only a) proportion of forage in diet; b) manure management system; and c) replacement rate.

- Consideration of the spread of farm practices within and between defined farm systems. A system typology needs to be defined that minimises the overlap in order for it to be meaningful.

- Consideration of the potential uncertainty and self-selection bias in farm and industry recording systems and the consequent fitness for use in the improved Inventory methodology.

- Consideration of how to achieve a standardisation of new and existing data sources across the UK – to simplify the integration and interpretation of data sets.

- Consideration of how best to integrate the GHG and ammonia emissions inventories to share and standardise on sources of data describing farm practice and the consequences of mitigation for both ammonia and nitrous oxide emissions. This was also emphasised in informal feedback from Defra after the workshop.

- More quantification is required in the definition of terms such as ‘low’ and ‘high’ slaughter weights in order to clarify whether differences between systems are actually significant for GHG emissions rather than a statistical nicety.

- Consideration for how proxies for change in management practice (for example sales of seed for high sugar grasses as opposed to survey data on actual sown area) can be effectively used in the improved Inventory.

- Consideration of how participation in agri-environment schemes should be represented in the Inventory structure – especially how it affects the implementation of mitigation methods.

- Consideration of which improvements in practice would be captured implicitly by the Inventory methodology and national data sets and therefore do not need investment in data capture except where it is necessary to collect data to be able to *explain* how improvements in production efficiency have come about. For example, efficiency of production and increased number of surviving lambs per ewe might be implicitly captured by a reduction in the number of ewes recorded by agricultural census for the same level of production. Similarly the improvement in nitrogen use efficiency would be revealed implicitly by reductions in the use of fertiliser recorded by the BFSP and so there is not a need to attempt to explicitly measure this efficiency gain and/or the changes in farm practice that drive it – such as use of a fertiliser recommendation system and regular manure and soil testing.

Finally, it was emphasised that it is critical to be able to assess the sources of error in all sources of farm practice and activity data used in the farm systems descriptions. It is important that the error can be characterised to enable formal uncertainty analysis

of Inventory calculations to report on the change that we can be confident has occurred.

This workshop has therefore provided valuable feedback on the farm systems descriptions and mitigation methods to be used to aid structuring the improved Inventory. The AC0114 project is dependent on continuing support and expertise in government and industry throughout the UK. We welcome your feedback on this workshop and your future expert input. This project has representatives distributed throughout the UK and we are willing to make presentations at seminars and stakeholder meetings to share data and expertise.

Feedback and further discussion by contact with:

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