Agriculture

Agriculture is responsible for 43% of methane emissions (0.91 Mt) making it the largest methane-emitting sector in the UK.[63] Emissions arise entirely from the livestock sector, almost 90% of which are a direct result of the digestive processes in livestock mammals[121] (enteric fermentation). The remaining 10% arises from manure management practices which promote anaerobic decomposition of waste. Non-livestock agriculture is not a measurable source of methane in the UK.

Emissions from the agricultural sector are declining slowly, being 13% lower in 2002 than 1990. This is not so pronounced as emissions reductions achieved by other sectors. As a consequence, the relative importance of methane emissions from agriculture has grown. Policy measures will be required to achieve substantial cuts in emissions, but implementing such policies is a major challenge.

The UK livestock industry has suffered greatly in recent years, with both the BSE (bovine spongiform encephalopathy) and Foot and Mouth crises damaging consumer confidence and profitability of farms. The UK farming industry is regarded by the public as a vital component of the UK economy, so any policy measures introduced must reflect this and not penalise an already strained industry. Furthermore, there is public mistrust of the effects of agri-technologies and large scale agri-business, as exemplified by BSE, Foot and Mouth, and genetic engineering. Any mitigation measures actively promoted by the Government should reflect these concerns.

Table 15: Methane produced by enteric fermentation and manure management (kg methane per head per year)

Animal	*Enteric fermentation*	*Manure management*
Dairy cows	115	13
Beef	48	6
Other cattle > 1yr	48	6
Other cattle < 1yr	33	6
Pigs	1.5	3
Sheep	8	0.2
Lambs < 1 yr	3.2	0.1
Goats	5	0.1
Horses	18	1.4
Poultry	Not estimated	0.1
Deer	10	0.3

Source: National Atmospheric Emissions Inventory, 2004[122]

6.1 How is methane produced?

Methane emissions from the agricultural sector derive from two sources: enteric fermentation and manure management practices (Table 15).

Enteric fermentation

Methane is produced as a result of the natural digestive processes in ruminant mammals (those that chew the cud), such as cattle and sheep. Unlike humans and other non-ruminant mammals, ruminants are unable to digest their feed entirely, particularly cellulose-based plant polymers, by the action of stomach enzymes alone. Instead, ruminants have an expanded gut (the retrulo-rumen) in which feed is broken down by bacteria and ferments prior to gastric digestion. In an adult ruminant, the rumen comprises approximately 85% of the stomach capacity and typically contains digesta equivalent to around 10-20% of the animal's weight.[26, 123]

Food is retained in the rumen for a considerable period of time where, in the presence of a large and diverse microbial population, it is anaerobically fermented to form volatile fatty acids, ammonia, carbon dioxide, methane, cell material and heat (Figure 17). The balance of these products varies between animals and with dietary intake, being largely determined by the composition and activity rates of micro-organisms present in the rumen. The gaseous waste products are mainly removed by the process of eructation (burping) or eliminated as part of the respiration process.[124] Less than 10% is emitted as flatus (farts).

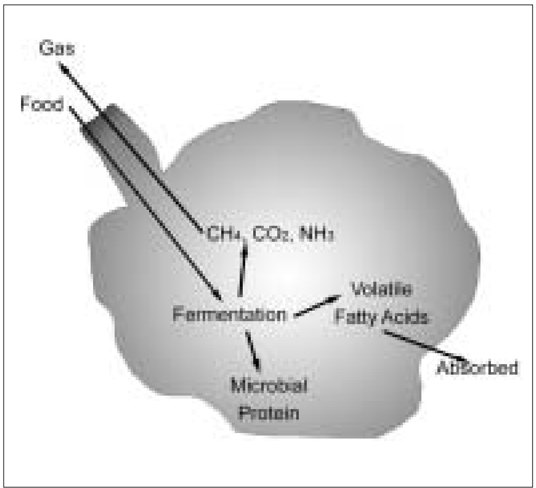


Figure 17: Enteric fermentation in ruminant mammals

Non-ruminant mammals do produce some methane as a result of digestive processes, but at far lower rates. For example, pseudo-ruminants (such as horses) do not have a rumen, yet ferment feed during the digestive process to enable them to obtain essential nutrients from plant material. Mono-gastric animals (such as pigs) also produce small quantities of methane during digestion.

Manure management

Modern manure management systems tend to restrict the availability of oxygen to the waste, promoting the production of methane. Anaerobic manure management is associated with intensive agriculture, particularly dairies and pig farms where large numbers of animals are contained within a single, relatively confined facility. The high density of animals leads to the production of large quantities of waste, which is typically washed out into tanks, lagoons or pits where it is stored as a liquid or 'slurry'. Being liquid, air is excluded and waste decomposition takes place under predominantly anaerobic conditions, resulting in the production of methane.

The amount of waste produced is dependent upon the number and types of animals, along with the quantity and quality of food consumed. The precise amount of methane produced from any given animal waste is dependent upon a number of factors, most notably the quantity and composition of the waste, which, in turn is dependent upon the type of animal and feeding practices. Ambient climatic conditions are also important. Increased temperature promotes biological activity, thereby enhancing methane production.

6.2 Mitigating emissions from livestock

Emissions from livestock are a diffuse source and as such are not easily captured or quantified. Therefore mitigation strategies for this sector focus on reducing production at source. Methane production from animals is dependent on a number of factors, represented simply as:

Total emissions =
Number of animals
x Lifetime of animal
x Emissions per head per day

The overall emissions may be reduced by altering any of the above parameters: reducing livestock numbers, reducing the emissions per animal, or achieving the same product yields over a shorter lifetime. There is a range of management and technological options available, some of which will alter more than one of these parameters at once.

Methane from animals is a waste product, representing a loss of dietary energy available to the animal of 2-12%. As such, the production of methane both directly from enteric fermentation and from the decomposition of organic animal waste, is a reflection of the inefficiency of the digestive process. Consequently, methane emissions can be reduced through productivity improvements, which also offer potential cost-benefits to the agricultural sector. Increased productivity can be achieved through increasing the yield of meat or milk from an animal over the same lifetime, or attaining the same yields in a shorter lifetime. Both have the effect of reducing the overall methane production per mass of product. This requires nutritional adjustments, such as changes in diet and use of feed supplements, or genetic modifications. These options are discussed in more detail below. However, the applicability of these techniques in practice is limited by a number of factors, namely: risks to human health; consumer acceptability; animal welfare issues (particularly risks to animal health and development); ethical considerations; and cost effectiveness.

Dietary adjustments

Improved nutrition and dietary adjustment in order to optimise rumen and animal efficiency is a growing area of interest in terms of both environmental and productivity benefits. Methane emissions depend on the average daily feed intake and efficiency with which feed energy is converted into product (meat, milk). This in turn depends upon the efficiency of rumen fermentation and the quality of the feed. Improvements to the quality of animal feedstuff, particularly in terms of digestibility and energy value, or improvements to rumen efficiency provide two potential routes to methane reductions.

Feed quality

Feed conversion efficiency – the rate at which feed energy is converted into product rather than waste – is higher for certain types of feed. For example, grain feeds are converted more efficiently than forages (grass), as they are relatively easy to digest and have a high energy content.

Rumen efficiency

Efficient digestion requires a diet that contains essential nutrients for the fermentative micro-organisms. If nutrients such as ammonia, sulphate and phosphate are limited, digestive efficiency will diminish, resulting in increased emissions of methane. Nutritional supplements can therefore be used to enhance dietary nutrition. In some cases this has resulted in increased milk yields of 20-30% and increased growth rate of 80-200%,[26] with typical methane reductions of up to 40% per unit output. The largest gains from nutritional supplementation are likely to be amongst animals on low quality feeds: in tropical areas with chronic feed constraints, supplements can result in emission reductions of up to 75%. In the UK, where ruminants have relatively high quality diets, this potential is more limited. Nevertheless, a number of advanced supplements, in the form of chemical and pharmaceutical additives, have been developed which have the potential to deliver further efficiency or productivity improvements. This may not prove a popular option given the growing consumer backlash against the use of chemical additives in recent years and a number of such substances have already been prohibited from use in the EU and elsewhere.

The extent to which dietary adjustments and supplements could achieve methane reductions in practice is largely dependent on the real and perceived risks to human and animal welfare, along with the economic cost.

Genetic improvements

Selective breeding can result in significant improvements to the genetic characteristics of ruminants, such as digestive efficiency and productivity, although developments have been hindered by associated problems with fertility, lameness, mastitis and metabolic disorders.[26] Arguably, greater scope exists with improvements to reproductive efficiency, which could significantly reduce the large numbers of animals which typically comprise a reproductive herd. The UNFCCC (fact sheet 271) reports that pilot projects in India have achieved increased birth rates as a result of improved feeding practices: the interval between births was reduced by almost half, from 24 months to 12-15 months. There have also been suggestions that genetic engineering could achieve methane reductions from ruminants by

There is widespread opposition to genetic engineering in the food chain

increasing fermentation efficiency through adjustments to rumen micro-organisms.

However, there remains strong public resistance to genetic engineering in the food-chain due to both ethical objections and scientific uncertainty regarding associated risks and knock-on effects.

Reducing livestock numbers

Fewer animals will result in a reduction in methane emissions from both enteric fermentation and manure management. However, this is a highly contentious and politically troublesome option, especially after the BSE and Foot and Mouth crises have strained the UK livestock farming industry. Attempts to force a reduction in livestock numbers are unlikely to be successful; in New Zealand, proposals to introduce a tax on livestock to reduce emissions proved so unpopular the measure was withdrawn. Any drop in numbers would also need to be matched by a corresponding drop in consumer demand for meat and animal products, otherwise production and methane emissions will merely be displaced to other countries.

There are signs of a shift in consumer preferences with a change in demand for meat and animal products. Within the UK, as well as a number of other European countries and the USA, there has been a noticeable move away from red meat towards poultry, along with a growing vegetarian movement and support for organic produce. Whilst this has been greeted optimistically by some in terms of the wider implications for sustainability, including potential greenhouse gas emissions reductions, the true benefits remain unclear. In particular, the stability of this trend, the wider implications for the economy and agricultural sector, and the complex knock-on effects for the environment and sustainability are uncertain. Because of the relative emissions factors (Table 15), minimising consumption of dairy products is more significant than minimising meat consumption, in terms of greenhouse gas emissions. However, this would be a difficult area to legislate.

Organic farming requires lower livestock densities through tighter controls on animal welfare standards. An *individual* farm turning organic would therefore have to reduce stock numbers to comply with these standards, but would retain income due to the premium paid by consumers for organic produce. However, this may not reduce livestock numbers across the whole agricultural sector if other farmers increase their herds in order to supply the same level of consumer demand for meat and milk.

Therefore, neither enforced reductions in agricultural production levels or consumer demand are considered to be realistic or viable routes to long-term methane emission reduction.

6.3 Mitigating emissions from manure management

Reductions in methane emissions from manure decomposition can be achieved simply by modifying waste management practices. Several waste management techniques are available which favour aerobic decomposition.

Dry deposition

The 'dry deposition' (land application) of waste is a widely practised, relatively low-tech option, which enables value to be recovered from waste as a fertiliser. In order to minimise any opportunity for anaerobic decomposition, the manure needs to be spread as soon as possible following production and collection. The IPCC report that, for the average EU climate, daily spreading of manure results in the release of 0.1 to 0.5% of the manure's methane potential compared to 10 to 35% from conventional manure management practices.[26] However, land spreading of waste is not without problems. In particular, this practice is associated with relatively large ammonia and nitrous oxide emissions and risks eutrophication of nearby lakes and rivers from nutrient-rich run-off.

Composting

Composting offers another low-tech option for managing manure. Liquid waste can be dried, making the waste suitable for composting. If necessary, other dry organic material can be added to the waste. However, for air penetration to be maximised, and therefore anaerobic decomposition minimised, the compost must be regularly turned.

In the case of both dry deposition and composting, the complex organic compounds within animal waste are broken down naturally by bacteria, releasing carbon dioxide. This is part of the natural carbon cycle, the carbon dioxide being originally absorbed by the plants used as livestock feed during photosynthesis. However, both techniques are likely to require energy input (for the mechanised processes) and therefore any associated greenhouse gas emissions should be deducted from the total methane savings. These options may not be appropriate because they both require a certain amount of space; methane emissions from manure management are generally associated with intensive farming facilities dealing with large quantities of waste within a confined area.

Aeration of liquid waste

A more practical way of reducing methane production may be through the aeration of liquid waste. By increasing the levels of dissolved oxygen within liquid waste, typically using mechanical pumps, aerobic decomposition is encouraged. Again, this process requires substantial energy input, with implications for greenhouse gas emission savings. Furthermore, this process has been linked to increased nitrous oxide emissions.

Methane capture

In reality, it is often preferable to capture methane emissions from the manure management practice rather than attempt to prevent them. Technologies to capture and dispose of methane arising from manure management practices are similar to those applied to landfill and have proved highly successful. Waste pits or lagoons can be lined and covered with impermeable materials in order to contain and collect the methane. Whilst this option has the advantage of being relatively low-tech, it does require space and the gas capture rate may be fairly low due to problems associated with sealing large areas.

Anaerobic digestion

A better rate of methane capture is achieved by purpose-built anaerobic digesters, which operate according to the same principles as those used within the solid waste management process, optimising decomposition of manure for methane production and collection. The IPCC report that anaerobic digesters typically release just 5% of the total methane potential of the waste, most of which comes from further decomposition of the waste residue once it has been removed from the digester.

Digesters have become increasingly popular within the agricultural waste sector, bolstered by the range of benefits offered by this technology. By heating the vessel to around 60°C, the production of methane can be maximised over a relatively short period, decreasing retention time of the manure from around 60 to 20 days. The biogas generated can be recovered for its energy value, improving the cost effectiveness of this practice. The resultant gas comprises approximately 65% methane, which can either be combusted directly as a local source of fuel or else used to generate electricity for use onsite or for sale to the grid. This process ensures that methane is converted into carbon dioxide prior to emission and also offsets greenhouse gas emissions from the equivalent energy supply from coal or oil. Furthermore, the electricity generated is eligible for ROCs, providing an important financial incentive to implement digester technology as well as being an additional revenue stream for the agricultural community.

Other benefits of managed anaerobic digestion include reduced contamination from runoff, removal of noxious odours, lower levels of pathogens and retention of the organic nitrogen content of the manure. This means that the residue is a valuable organic fertiliser. Other products contained within the effluent have been successfully used for animal feed and as aquaculture supplements. Such advantages may make anaerobic digesters an attractive option even if energy recovery is not possible. In these cases, the collected gas can be flared prior to emission, oxidising methane to the less potent carbon dioxide.

The UK's first dung-fired power station is in Holsworthy, Devon. It collects 146 000 tonnes of slurry per year from 27 local farmers and has a capacity of 1.4 MW, with the waste heat used for a community heating scheme. The project was relatively cheap, receiving £3.5m in EU grants, coupled with matched funding from a German biogas company. The intention is to introduce 100 such plants across the UK.[125]

6.4 Existing EU and UK policy

There is currently no agricultural policy in the UK specifically targeted at mitigating methane emissions. Reductions in emissions have been achieved fortuitously through policies aimed at other objectives, such as nitrate pollution and manure management.

Most UK agricultural policy is based on the EU Common Agricultural Policy (CAP). Introduced in the 1960s, the CAP was intended to decrease dependence on imports and deliberately increase domestic food production through a system of subsidies paid to EU farmers. Other mechanisms used by this policy were market management to decrease surpluses, and import taxes and export subsidies to protect the domestic market, thus ensuring food security and a fair standard of living for those dependent on agriculture. The subsidies have resulted in some overproduction, often at the expense of the environment, by encouraging a more intensive form of agriculture and so adversely affecting the amount of methane produced.

The policy is also expensive, costing the EU £28.5bn per year. It has been estimated that every head of cattle in the EU is subsidised by £1.40 per day.[126] The UK receives 9% of available CAP funds (some £3bn in 2000-2001), but overall is a significant net contributor to the policy.[127]

The CAP is currently undergoing major reform[127] as it is considered unsustainable in its present state. These reforms are unlikely to reduce costs but may decrease methane emissions by reducing livestock numbers. The EU has suggested 'decoupling' direct payments to farmers (or separating payments from production) so that farmers are encouraged to farm for market demand rather than the subsidies available. Removal of subsidies should lead to higher prices and preserve farm income. Studies investigating the impact of decoupling indicate that the recent proposals will result in reduced agricultural production and livestock numbers.[128-130] A further reform of arable and dairy market regimes will reduce intervention price support while partially compensating farmers for income loss through increased direct payments.[131] This is likely to further reduce livestock numbers and therefore methane emissions.

Another policy that influences emissions from the agricultural sector is the Integrated Pollution Prevention and Control (IPPC) Directive discussed in Chapter 5. This Directive extends the pollution control regime to the UK agriculture sector by covering intensive pig and poultry installations. Again, this policy does not specifically target methane, its focus being more on reducing ammonia, but since it covers manure management and production, it will also have some impact on methane emissions.

6.5 Recommendations

Whilst the agriculture sector is responsible for the majority of methane emissions in the UK, it is also one of the most difficult in terms of emissions reduction legislation, reflected in the current lack of such policies.

Emissions from livestock

Methane capture is not a realistic option for livestock emissions. Of the options for reducing emissions, neither lowering livestock numbers nor promotion of agri-technologies appear to be particularly attractive or feasible politically. Policies must be acceptable to the UK farming industry and publicly acceptable in terms of food safety and other environmental issues.

Reducing livestock numbers via direct policy measures would be unacceptable to the farming industry, who would view it as a loss of income. It is possible that the CAP reforms may help to reduce livestock numbers through the removal of subsidies thus preventing overproduction, although to what extent is unclear.

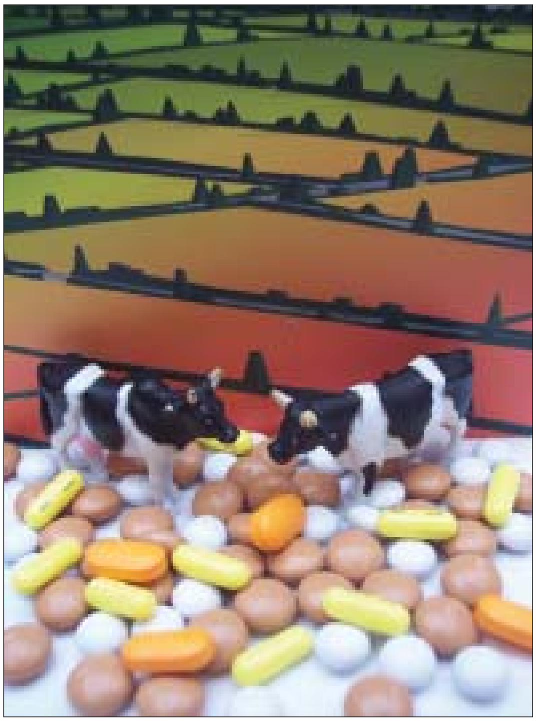
The current social trends towards organic produce, lower meat consumption and vegetarianism could help underpin any reductions in animal numbers, although they are unlikely to be major factors by themselves. Such trends could be encouraged through educational programmes focused on lower red meat and (especially) dairy consumption, linked to the corresponding environmental and greenhouse gas benefits.

Organic farming is a farming system that best addresses many policy objectives for agriculture and has a strong growth potential given continuing consumer demand. Supporting a move towards more sustainable methods of farming may help towards decreasing livestock numbers.

Policies encouraging emissions reductions through improving livestock productivity and efficiency may find support amongst the agricultural community due to increased profits. However, such policies are unlikely to be popular with the public, who, in general, wish for a more natural form of agriculture with a minimum of chemical or biotechnological inputs into the food chain. The widespread rejection of genetic engineering in this country and Europe, coupled with fears over food safety following the agricultural practices that led to the BSE crisis, mean that any direct promotion of such measures to reduce methane emissions are likely to be viewed with distrust.

Further research is required into the opportunities for productivity increases and methane emission reductions from animal dietary changes. This should be conducted within animal welfare guidelines, taking into account public acceptability of agri-technologies such as genetic engineering.

In essence, as far as agricultural emissions from enteric fermentation are concerned, there is a trade-off to be made. Some reductions will occur as part of the CAP, but any further reductions in methane are likely to be difficult to achieve without alienating the farming community or the general public. Faced with such an impasse, it may be necessary to accept that the livestock industry is sufficiently important to the UK and that a certain level of methane emissions will always be produced by agriculture. This shortfall can be made up by simpler, more cost-effective reductions in other methane generating sectors.



Food supplements and growth hormones can cut methane emissions. But do the public want them?

Manure management

Policies targeted at reducing methane emissions through improved manure management practices are more straightforward. In this case, the methane is capturable and therefore can be used to generate electricity or fuel gas-fired equipment. Best-practice technology exists in the form of anaerobic digesters and a strong financial incentive to support this technology is already available through ROCs.

The main barrier to widespread implementation at present appears to be lack of knowledge about the technology or conservatism within the sector. This could be overcome through education of the farming community about the positive benefits of anaerobic digestion, further supported by grants or long term low-interest loans to reduce the initial costs of capital equipment, similar to those under the Clear Skies Programme. Assistance in setting up farming co-operatives with shared digester facilities would also aid the development of community level anaerobic digestion schemes.

Methane trading

Trading of emissions from livestock is unlikely due to the scattered and diffuse nature of methane producers, making capture difficult. Emissions from this sector are hard to quantify, being based on estimates of emissions factors from different animals and feedstocks. Verifying any emissions reductions would also prove complicated.

A further barrier to trading from the agricultural sector is the small size of players – traders require larger quantities than individual farmers would be capable of producing. Such players would therefore not be capable of participating effectively in a trading scheme, especially the EU Emissions Trading Scheme which focuses on large scale emitters. Some form of aggregation would be necessary, but this would be likely to be so complicated as to be ineffectual.