Improving Production and Reducing Greenhouse Gas Emissions

Mair Morgan

Hybu Cig Cymru Scholar

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Why this topic?

The Kyoto Protocol was implemented in February 2005. Under this international agreement the European Union committed to reduce greenhouse gas emissions (GHG's) by 8% by 2012 and a further 18% reduction by 2020. Carbon dioxide is the most abundant greenhouse gas but has the least Global Warming Potential (GWP). Nitrous oxide has the most GWP 298 times that of carbon dioxide and methane is 25 times more potent than carbon dioxide.

It has been estimated that agriculture accounts for 10–12% of global anthropogenic GHG emissions, with agricultural land accounting for 50% of methane (CH_4) and 60% of nitrous oxide (N_2O) emissions.

Agriculture is only responsible for 7% of GHG's in the UK; however there is a public perception which is encouraged by some interest groups that livestock farming is the major source of GHG's in the UK. Ruminants in particular have received negative press on GHG emissions, with some celebrities making calls for the public to stop eating red meat in order to reduce livestock numbers and consequently reduce GHG emissions.

If we focus on methane emissions, UK agriculture is responsible for 38% of methane emissions. In Wales, agriculture contributes 57% of methane emissions, of which 84% is from enteric fermentation of cattle and sheep and 16% from manure management.

There are a number of ways to reduce methane emissions, and the one that is most favoured by the public is to reduce cattle and sheep numbers. However, there are many other options such as improving performance per animal, improve feed conversion efficiencies and improve genetics to reduce emission intensity. Generally, the higher the dry matter intake (more concentrates), the less energy is lost as methane. However there is a variation in animals, most animals will eat more than they actually need. It may be possible to select animals that consume only what is required for maintenance and growth.

I feel that Welsh agriculture should investigate ways of reducing GHG's without compromising the final product or affect farm profit. I strongly feel that reducing GHG emissions goes hand in hand with improving efficiencies and farmers could improve physical and financial profits of their farm at the same time as reducing GHG's. The increasing world population will increase the demand for food and we need to ensure that GHG's don't increase. Reducing GHG's is also something that processors and consumers are starting to demand.

There are a number of small steps the Welsh red meat industry could take to reduce methane emissions such as improving fertility, health and longevity of animals. A reduction in mortality of animals will reduce the number of animals needed and the number of replacements kept, overall reducing emission intensity. Reducing wastage in the carcass will also reduce emissions. Best practice manure management such as covering slurry stores, applying manure to the ground when the crop requires the nutrients and injecting slurry will also reduce emissions and have financial benefit to farmers.

The Welsh red meat industry needs to reduce their emissions to keep up with other countries in the World, other livestock sectors in the UK and to become more economically viable.

Increasing productivity = lower production costs & lower emissions.

Why Australia & New Zealand?

Agriculture in both New Zealand and Australia is far more important to their national economy than it is in the UK. The GHG emissions are also considerably higher. Cattle and sheep account for 13% of Australia's GHG's and 30% of New Zealand's GHG's. 49% of NZ's GHG emissions are from the agriculture sector. 95% of agriculture emissions are from ruminant animal methane emissions and from nitrous oxide produced from animal waste and fertiliser. Consequently there is more of an emphasis for Australia and New Zealand to reduce agricultural GHG's and as a result there is a considerable amount of money being invested in research to reduce agricultural GHG's in these two countries.

Australian researchers are taking forward the concept of residual feed intakes and have demonstrated that there is a heritable component that can be selected and they are now breeding for low emitting animals. They have also looked at dietary supplementation and whole production systems with various management systems.

New Zealand is now leading the way with GHG emission research since they set up the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGGRC). They have developed inhibitors of nitrification for application to land to reduce N_2O emissions. They are also breeding animals for low methane emissions and testing alternative diets and forages on methane emissions.

Both New Zealand and Australia have new legislations coming into place that will see landowners trading carbon credits.

Importance of agriculture to the countries

Agriculture is very important to both Australia and New Zealand. The New Zealand red meat sector is a principle driver of the New Zealand economy generating nearly NZ$8 billion annually in export earning. Consequently the government invests a considerable amount of money in agriculture. However, the red meat sector is under threat from competing land uses that provide better returns, in particular dairy and forestry. New Zealand is the largest lamb exporter in the World.

Australia is the largest exporter of mutton and live sheep and the second largest exporter of lamb and beef. The total value of Australia's off-farm beef and sheepmeat industry is A$16 billion. A smaller proportion of people are involved in agriculture in Australia compared with New Zealand. Australia provides considerable financial support for students studying agriculture in Australia and offers some interesting degrees such as Agriculture Biosecurity and Managing Change.

General beef and sheep farming

Australia

The Australian national sheep flock is around 68 million head (42.3 million breeding ewes); this is down from the historic high of 170 million reached in 1960. The focus of the Australian sheep industry has changed considerably in recent years with the focus moving from wool, to meat and wool, preferably without losing the quality of wool. Many farmers are now using terminal sires such as Border Leicester, Poll Dorset, White Suffolk, South Down, Dorper, Hampshire etc on Merino ewes. Border Leicesters are the most common first cross on Merino's followed by other terminal sires on these first cross ewes. On many farms, up to 70% of farm income has historically come from wool production. It is now estimated to be worth around 15% of the farm income.

Merino Ewes

The pure Merino ewes lamb at around only 80%, while many of the crossbred farms I visited were achieving 170% scanning and 150% marking. The farms I visited varied in size from 2,500 to 4,000 acres with 2,500-5,000 ewes. Most farmers shear their ewes four months pre-lambing to increase feed intake and lamb size. Many farms were also shearing lambs under 40kg at weaning to encourage growth post weaning. Sheep generally took priority over cattle on these farms with cattle being used for grassland management, parasite control and as an asset for the bank!

One enterprise I visited had an interesting weaning method. Lambs from one flock of ewes are moved at weaning time to another flock of ewes e.g. flock 1 lambs go to flock 2 ewes, flock 2 lambs go to flock 3 ewes. This was believed to reduce the stress on the lambs and resulted in higher growth rates post weaning.

Some of the farms I visited managed to sell 30-50% of the lambs finished by weaning. They all made sure that all lambs were off the farm before winter (April) to ensure they don't affect the next year's lamb crop. Many lambs are sold between 48-50kg liveweight (21-23kg deadweight) with some taken up to 55kg liveweight (24-26kg deadweight). 50% of animals in Australia are sold through the market with some lambs going to feedlots to finish. A considerable amount of animals are purchased through online auctions mainly due to the distances between farms in such a large country.

Merino cross Border Leicester ewes and Dorset cross lambs

Selection is aimed at producing prime lambs that have low birth weights, but high growth rates to allow early sales of lambs that have large loins with a fat covering to enable quick finishing and enhanced meat eating quality. Selecting animals with worm resistant qualities, good mothering ability, early milking, high lamb survival and early sexual maturity are also important factors in Australia. These all contribute to reducing emission intensity. All farmers look at the Australian Sheep Breeding Values (ASBV's) when selecting a ram. The Information Nucleus held with the Sheep CRC (Co-operative Research Centre) consists of a series of flocks located at eight research sites in widely differing environments across Australia. The information nucleus provides new information about traits and their genetic makeup.

Different areas of Australia lamb at different times of the year. This allowed farmers in the area I visited (New England) to purchase their replacements at 8 months old, tup them at 12-13 months old and lamb for the first time at 17-18 months.

In the area I visited in New England, Australia, some farmers fed ewes and lambs concentrates and other purchased feeds e.g. lupins and grains. This is a preferred and cheaper option than conserving forage. Silage and hay have been made in the past to feed over the winter months and is considered a very expensive option, therefore is no longer practised in this area. Forage conservation is more popular in other areas of Australia where machinery and contractors are more readily available. Fodder crops are a popular option for finishing lambs and steers on, as well as growing rams on some studs.

Weeds are a considerable problem this year (2011) because it has been so wet. They would usually slash them (top) but it has been too wet to slash. The main issues in the Australian sheep industry are foxes, dingos, varying rainfall patterns, worms, flies, lice, barbers pole worm, Johne’s disease and brucellosis. One farm said he was struggling to control foxes because it is mostly cattle farms around him and they are not doing anything to control them. It is thought that his marking percentage has dropped 10% due to losses attributable to foxes. If there were dingos in the area they could not farm sheep due to high losses. This is a real concern because the areas that dingos cover are spreading. They are now getting rain at different times of the year and the length of time between rain is increasing. To try and control Johne’s and brucellosis farmers can only buy sheep from areas with the same status as the area they are in.

Lamb prices in Australia in 2011 were at a record high at over $110 compared to $96 in 2010 and $65 in 2007. This is thought to be due to the demand in Australia and export value of certain parts of the lamb.

Australia Cattle systems

The Australian beef cattle herd is around 26.6 million head, down from a high of 30 million in the 1970s. Dairy cattle contribute an additional 2.6 million head to the cattle herd. Some of the farms I visited only purchase cattle for the summer months for grassland management. Some of these were again purchased through online auctions. Angus is quite a dominant breed mainly due to the premium price achieved with them. This makes them expensive to purchase but it is believed to be cost effective. Most cattle are finished in feedlots with only cull cows going direct to the abattoir from the farm. Many of the feedlots are owned by processors. They sell cattle depending on the availability of grass and the money in the bank. Some of the farms I visited had up to 150 breeding cows and 800 finishing cattle.

Many farmers felt that mixed grazing is key for grassland management. Some use cattle to prepare fields for lambs after weaning if it is a wet season and there is a lot of grass. The farms I visited only really have cattle to keep the grass down and reduce parasite burden.

Farms with breeding cows always purchase high performing Breedplan bulls on the B3 index with bull selection focussing on low birth weight, high 600 day weight, intra muscular fat (IMF) and carcass weight. Again all the attributes contribute to reducing emission intensity.

New Zealand

The sheep population in NZ has decreased rapidly from 68 million in 1980 to 57 million ewes in 1990 to 33 million in 2011; however they are still producing the same number of lambs now compared to the 1990's when they had significantly more sheep.

The farms I visited had between 4,000 and 38,000 ewes. Romney's are still the dominant breed (accounting for 46% of the national flock) despite numerous other breeds being present e.g. Perendales (11%), Corriedale's (2.4%), Coopworth, Highlanders, Primera, SuffTex and Cheviots. Merino sheep account for 4.5% of the NZ flock and are predominantly farmed in the South Island high country. Some farms have reverted back to traditional breeds after experimenting with some of the new composites. Others are adapting their systems and find that these composites and crossbreds are the way forward.

Merino rams

The average NZ lambing percentage is 112%. However, many of the farms I visited were achieving scanning rates between 165% and 195% and all were excellent grassland managers. Some were moving ewes every 2-3 days pre-tupping and during tupping to achieve these high scanning percentages. New Zealand farmers make excellent use of forage crops, maize silage, oats and peas and they considered chicory and plantain as rocket fuel for finishing lambs. Mob stocking is common practice on many farms. Very few farms feed silage or any other supplementary feed to sheep. Brassicas are planted for ewes to feed on over the winter.

Romney Rams

Most ewes in NZ lamb during September. Some lamb as early as June and some as late as October. Most lambs in NZ are then sold between December and April. Most of the farms I visited sorted lambs into weight batches at weaning using automatic shedders (3-9 ways). One farm I visited sold all lambs over 33kg at weaning, lambs that were nearest finishing were put on the best fields, (often referred to as the flats) and then when these lambs are sold the next heaviest group are moved on to these fields. Many farmers were achieving daily liveweight gains (DLWG) over 300g on the best fields and 150g DLWG on the hills. Many farms were weighing lambs every 10 days to check they were improving. Some of the lighter groups (e.g. under 26 kg) were not given as much attention for a little while. One farm I visited in NZ had sold 60% of his lambs before weaning. Many farms I visited aim to get all lambs off farm by March to focus on getting the ewe hoggets up to weight to go to the ram and to get good grass for the ewes pre tupping. Some farms put all the ewe hoggets to the ram but they don't keep anything that doesn't take to the ram. They often aim for an 80% conception rate with the hoggets. Lambing ewes as hoggets can reduce emission intensity and is known to improve the productivity of the ewe over her lifetime.

Five way automatic shedder

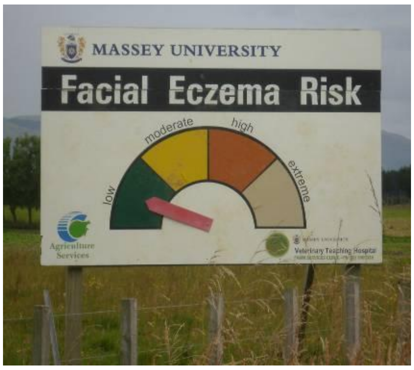
The electronic weighing systems and automatic drafters were able to weigh and draft around 400 - 500 per hour, with only one man operating. Lamb carcase weights are quite low with the average around 18kg deadweight. This is slowly increasing.

The farms I visited all had various shearing times. Some of them shear every 12 months, some every 8 months and some every 6 months. As the price of wool decreased some people moved to shearing every 12 months but now, as the price is increasing again, they are moving back to every 8 or 6 months. If farms do shear every 6 or 8 months they do not tend to shear the entire flock at the same time to reduce the risk of the whole flock being affected should the weather turn during winter months. Most farms shear lambs between 3 and 5 months to improve growth rates. Improving growth rates and time to finish can reduce emission intensity. Wool is worth around 12% of the farm income.

Despite EID not being compulsory in NZ, a number of farms are adopting it and seeing the benefits of recording details such as single/twin/triplet, mother's age, sire breed, health records, weights, yields from abattoir and lambs on different treatments

(Vitamin B12, different pasture). EID has been used on some farms for 12 years. Dock weight, weaning weight and post weaning weight is all recorded. EID is used to select replacements; selecting multiples, and those with good DLWG. Keeping more efficient animals reduces GHG emission intensity. One farmer described EID as the best tool on the farm for calculating, measuring and analysing data and ultimately informing financial policy changes. He found that lambs on crops were 3kg heavier than those on grass. He has also found that lambs grew better on rape than chicory, plantain or a clover mix; however the yield was better from chicory. This has encouraged him to change his system to moving the lambs onto certain crops just for the last couple of weeks to get better yields and to improve growth rates. Lambs are weighed 10 days after putting them on crops to check they are improving, if they aren't doing well, they are put on a different feed. Most farmers are recording weights, animal health, DLWG and groups of animals on different forage with the EID system.

Some of the stud farms used EID to a greater degree recording all lambs that are tagged at birth and remarks are noted such as bad maternal instinct, small, dead or weak lambs which would mean they were not considered for future breeding. The next record taken is the weaning weight, then the eight month weight and the fleece weight at shearing. No lambs are kept from ewes that don't catch in the first oestrus cycle at tupping time.



The main issues in NZ are changing rainfall pattern, facial eczema (mainly North Island), worms, flies, lice, Barbers pole worm (mainly North Island), Johne’s and Brucellosis. Nematodirus is also an issue for lambs on the South Island.

Farmers in New Zealand were very positive, the recent price increase probably contributed to this. 2010-11 lamb sales averaged NZ$117 compared to $81.30 in 2009-10 and $53.61 in 2006-07. January 2012 lambs were $7.40 per kg compared to $6.11 in January 2011 and $4.58 in January 2010. They were hoping that hoggets would sell at $250 and old ewes are currently worth $4.50-$5 per kg at the works and ewes going through market are making $150+.

Due to these increasing prices of livestock people are investing more in fertiliser. Some farms had not applied fertiliser for a few years due to financial reasons. Consequently fertiliser sales dropped by around a million tonnes from 2007-08 to 2008-09. 2010-11 sales are now back up at 2007-08 levels. Most NZ soils need fertilisers especially phosphate and sulphur. Peak applications occur in spring and autumn. Some of the farms I visited applied fertiliser by plane and sprayed weeds by helicopter. One farm I visited also used helicopters for mustering sheep.

New Zealand Cattle

There are nearly 4 million beef cattle in NZ, predominantly on the North Island. There are a further 5.9 million dairy cattle in NZ. Most of the farms I visited focused on sheep and had some suckler cows that were mostly Friesian cross Angus or Hereford cross Angus. Charolais bulls were occasionally used. Some farms were also finishing dairy steers or grazing dairy heifers. Many farms had over 100 cattle with some nearer 300-600 and one with 1,000+. One station I visited sold 350 bulls each year and they still said cattle are only really kept to groom pasture for weaning lambs onto and for parasite control. They aim to kill steers at 18 months with a target kill weight of 300kg deadweight, 560kg liveweight. The finishing cattle are weighed once every 6 weeks and they check if they are hitting the targets or if there is a problem with worm burden or pasture. The mating target for heifers is 325kg at around 14 months and sometimes they are nearer 390kg. They have an annual sale of surplus in-calf yearlings (350 heifers). They fatten and finish the barren cows. A cow has to have a weaned calf at half its body weight e.g. 520kg cow has to wean a 260kg calf. Cows that do not achieve this are not kept for future breeding.

The cattle are kept for grassland management purposes and are always mixed in paddocks with lambs or hoggets, preferably not ewes as ewes keep the paddocks reasonably good, grazing shorter than lambs and have built up immunity to worms.

TB is the main health concern in cattle in NZ and possums are the main carriers. Some of the farms I visited occasionally suffer from drought and the cattle are often the first things to be sold to release forage.

Calves are often taken through to finish with a carcass weight around 270 to 280 kg dead weight. Some calves may go to a feedlot. These are predominantly Angus and are finishing from around 600kg to 800kg.

Goats are kept on some farms in certain areas to control weeds, mostly in central North Island. There are a total of 95,000 farmed goats in NZ of which 67% are in the North Island with the largest population in the Waikato region. It is estimated that two thirds of goats are kept on commercial sheep and beef farms.

Deer are occasionally seen on cattle and sheep farms. Deer are selective grazers and therefore cattle and sheep are used to clean up the pasture after deer have grazed it.

Australia and New Zealand
A considerable number of the farms I visited in both Australia and New Zealand were using electronic weighing systems to weigh ewes and lambs. They were weighing 500 animals per hour with only one man operating. Some of the research sites had used voluntary weighing system set up in a way that animals have to go through it to get to feed or water. This is considered useful in areas that the animals are not convenient to gather and bring into the handling pens to gather information such as DLWG. All the farmers said that the initial output for the equipment is costly but it saves a lot of man hours.

Sheep are set stocked for 6-8 weeks over lambing in both New Zealand and Australia with little assistance or disturbance during the lambing period.

Rams are generally sold on-farm in both Australia and New Zealand, sometimes up to 4 months before they are used. In Australia on-farm auctions are more common. All buyers are looking for performance figures. They select for early fast growing lambs to have as many as possible ready for slaughter by weaning. There are a number of selection parameters, performance and visual. Many buyers are looking for low worm egg counts and good growth weights.

Abattoirs

Australian abattoirs slaughtered 18 million lambs in 2011, 47% of which is exported. The abattoir I visited in Australia kills 5,200 sheep each day. 50% of the lamb and mutton is exported. This abattoir has previously exported 80% but due to the increasing home demand it is now exporting less. The Middle East (China in particular) is the biggest export market (accounting for 23% of export). They make use of as much as possible of the carcass with many different cuts to reduce wastage. The skins are sorted up to 30 different ways depending on wool length and breed, these are mostly sold to China and Russia. Most of the offal goes to Saudi.

NZ abattoirs slaughtered 19.7 million lambs, 4.6 million sheep, 2.4 million cattle, and 1.7 million calves in 2011. 92% of the lamb is exported, 91% of mutton, 82% of beef and veal.

I visited two abattoirs in New Zealand. One slaughtered 12,000 lambs a day, 10 per minute. The other abattoir I visited slaughtered 32,000 lambs per day during peak season. All animals are slaughtered according to Halal because a lot of meat is being exported to the Middle East. Most carcass weights are between 16.5kg-19.5kg. Some were 22kg but these were over fat and the farmer penalised. There is a high emphasis on yield in the three sections (hind/leg, middle/loin, fore/shoulder). Some carcasses are exported whole; however the majority go to the boning room. As the carcasses go into the boning room they go through an X-ray machine that calculates where to cut them into the three sections to get the best value for the carcass. The yield of each third is fed back to the farmer. This allows the farmer to see what area he needs to focus his breeding on. There is very little wastage. Some livers are condemned due to facial eczema, liver fluke or c. tenuicolis.

Viascan results

Abattoirs are funding trials with genetics, diet, growth rates, yield and castration status to assess production efficiencies and meat quality traits (taste, tenderness, aroma, colour, juiciness). Variation in forage appears to have the greatest effect. One trial has found that on two certain crops the females were found to have a poorer taste compared with the males. Females were slightly better than males on some other crops, but not to the same extent. The abattoirs also offer a service of carrying out post-mortems to look for any health issues that may help reduce the risk of disease on the farm.

The abattoirs are very much involved with the central progeny testing to improve genetics. The central progeny test evaluates the genetic performance of rams by comparing their progeny. The abattoir compares meat eating quality of the different breeds and rams. The traits measured include colour stability, pH, tenderness (chilled and frozen) and eating quality. The key findings from the trials to date are that genetic variation occurred in all meat quality traits measured. Colour stability and tenderness would be good candidates for genetic selection. They have also looked at meat eating quality and taste on meat from five different forages including high sugar grass, lucerne, chicory and brassicas.

The abattoirs are also developing an on-farm carbon footprint calculator (Hoofprint). They feel that Hoofprint and other information they provide the farmer with e.g. Central Progeny Testing, Viascan and best practice through farm assurance can improve production efficiencies and reduce GHG's. The abattoirs have also reduced CO_2 emissions from processing energy use per modified product weight. They were 26.4% lower in the 2010/11 season than in 2000/01. Total CO_2 emissions in 2010/11 were 2,866 tonnes less than in 2009/10. The abattoirs have introduced many processing energy efficient programmes and alternative energy projects in the plant as well as encouraging on-farm production efficiencies.

It has been calculated that the NZ lamb life cycle carbon footprint is 3% from meat processing, 5% from all transportation, 12% from consumer phase and 80% on farm.

Genetic improvement

Australia has put considerable emphasis on the Information Nucleus with the Sheep CRC (Co-operative Research Centre). The Information Nucleus consists of a series of flocks located at 8 research sites in widely differing environments across Australia. The information nucleus provides new information about traits and their genetic makeup. New traits include the horn-poll prediction, dressing percentage, lean meat yield and eating quality (intramuscular fat). The traits have been assigned Research Breeding Values (RBV's) which support the Australian Sheep Breeding Values (ASBV's). There are over 250 selection traits available, from the quality of wool to the quality of the meat to growth rates and survivability. However the main focus is on low birth weights, high growth rates, large loins, enhanced meat eating quality, worm resistance, mothering ability, early milking, lamb survival and early sexual maturity.

Genomics offers the ability to increase selection accuracy, the ability to select at younger ages reducing the generation interval, ability to measure difficult or hard to measure traits particularly the consumer satisfaction ones. This gives scope to manage customer satisfaction or quality traits, in particular eating quality and the nutritional content of meat.

Considerable focus is also given to cattle breed selection in Australia, in particular low birth weight, high 600 day weight, IMF and carcass weight.

New Zealand also puts considerable emphasis and effort into genetic improvement and the stud farms are particularly good at utilising this information. The selection criteria often used are lamb as a hogget, rear two lambs as a two tooth and onwards, efficiently wean at least their body weight per year, lamb unassisted, fast growth and early maturity, efficient conversion of grass to carcass, longevity (number and weight of lambs over lifetime) and selection for market required meat characteristics. Researchers have developed the CARLA test to identify the animals' immunity to parasites and are looking at other causes of parasite systems e.g. scouring, dags and ill thrift.

Current focus is on muscle and tolerance to facial eczema. New Zealand researchers and farmers have moved from breeding for resistant ewes to worms to breeding for resilience. The main reason for this is that resistant ewes/lambs often put considerable amount of their energy into the immune system resulting in reduced growth and poorer performance. Therefore the approach they now take is to extend the time when they would normally worm and not keep the tail enders for further breeding. They would drench when about 10-20% of the animals in the group are struggling with performance, but the rest are thriving. Every time they take a cull, they weigh and look at figures per sire, number of culls per sire and weight per sire to see if they want to use that sire next year. There is a slight benefit in breeding for resistance with a slightly greater fecundity/fertility. They have also found that breeding for resilience has resulted in a slight increase in wool production.

The priorities for selecting rams for breeding are survivability, reproduction, growth, meat, dag, parasite resistance/resilience. Before weaning they take a sample weight and aim to get an average weight of 30kg at 85 days weaning. DLWG are often up at 300g per day with the singles sometimes achieving nearer 400g per day. Many clients are now looking at the meat trait, growth and survival with some looking at reproduction value and dags.

Many of these selection traits are essential in reducing greenhouse gas emissions from the flock e.g. lamb them as hoggets, number of lambs (fertility), ewe liveweight, longevity, efficient conversion of grass to carcass. However, the three key priorities are early growth rate, lamb survival and internal parasites.

NZ cattle breeding focuses on 17 traits, mainly calving ease, gestation, birth weight, 200 day weight (gives milking ability), 400 & 600 day growth rates, carcass data (weight, eye muscle, rib fat, rump fat, IMF, retail beef yield) and mature cow weight. A cow has to have a weaned calf at half its body weight e.g. 520kg cow has to wean a 260kg calf. Cows that do not achieve this are not kept for future breeding.

Reducing GHG's

There are a number of ways to reduce greenhouse gas emissions (GHG's), many result in economic benefits and more productive systems to reduce emissions per kg of meat produced e.g. multiple rather than single lambs born, reducing time to slaughter, lamb as hoggets, longevity, efficient conversion of grass to carcass. Other things that have been tried and tested to reduce methane emissions are rumen manipulation, tannins, legumes, oils and limiting protozoa. Some commercial companies are also trying to produce products to reduce methane emissions.

Methane emissions can be measured in three ways; SF6, greenfix and the fixed respiration chambers.

In-vitro studies (studies in laboratory glassware) often show reduced emissions however this is not always the case at animal level.

Australia

Considerable research work has been carried out in Australia on reducing GHG's. Two new pieces of legislation have recently come into force in Australia and this is partly the reason for the considerable amount of research. These are The Carbon Farming Initiative (CFI) policy and the other is the Clean Energy futures. This allows a mechanism for landowners to offset carbon through mechanisms such as sequestration, improving soil carbon, planting trees, reducing methane emissions and reducing nitrogen. The idea is that landowners will be able to generate carbon credit units that they can trade. The accepted methodology must be followed and some of these have not been finalised yet as this only came into force on 1st December 2011. Various options for reducing emissions could include improving efficiency, reduce methane emissions, improve manure management and sequestration of soil carbon. However allocation of carbon credits will not be as straight forward as this. The aim of the CFI is to reduce emissions intensity. Improving efficiency may not count but if there is more product and less animals it might count.

Sheep chambers in Australia

They have measured emissions from both cattle and sheep in a chamber and in the field with SF6. With the chambers they can monitor feed intake, DLWG and emissions. They found that some cattle can gain weight (good DLWG) with less feed which makes the animals more productive and cost effective. Feed efficient cattle produce less methane and cost less to keep.

The University of New England has been looking at reducing methane emissions by genetic selection in sheep. It is thought that there is about 10% variation, maybe 30% when management and feed is controlled. They have also found a variation in rumen size and volume (10-40%) in these animals. They are investigating this further and breeding from low and high emitting ewes and rams to monitor offspring and calculate the heritability value.

Spectrophotometers have been used on research plots to compare methane emitted from sheep grazing nine productive/improved plots and nine less productive plots. These are infra-red cameras that certainly prove that only sheep emit methane emissions on the paddocks. As soon as the sheep were removed there were no emissions recorded. Nitrous oxide was also recorded on these plots. There are three lots of 32 ewes on the more productive areas and three lots of 16 ewes on the less productive areas. The three high productive groups are rotated around the 9 more productive plots every month, and 3 three less productive flocks are rotated around the 9 less productive plots every month.

New Zealand

New Zealand is now leading the way with GHG emission research since they set up the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGGRC) and the Pastoral Greenhouse Gas Research Consortium (PGgRC). The key objectives of the PGgRC are; rumen microbial ecology and rumen microbial strategies to reduce methane emissions, methanogen genomics, anti-methanogen vaccines, chemigenomics/inhibitors, exploiting animal to animal variation, ruminant nutrition, low GHG emitting farm systems and nitrous oxide mitigation.

PGgRc's key focus goal is to decrease total agricultural emissions of greenhouse gases by 10% per unit of output by 2013, relative to 2004. This is estimated to be a 4Mt reduction in the agricultural greenhouse gas emissions as identified in the National Inventory. Other targets include:

- To have 33% of farmers implementing at least one greenhouse gas mitigating strategy by 2013
- To help New Zealand farmers adapt to the effects of climate change, and to become competitive in a carbon-constrained global economy beyond 2012.

Between 2004 and 2010, PGgRc contracted over NZ$30 million in scientific programmes aimed at reducing GHG's.

The Agricultural Emissions Trading Scheme (Carbon trading) is also a reason for research in this area. A lot of decisions still remain to be made before the carbon costs are imposed and legislation is applied in 2015. It is likely that the processors will be the points of obligation e.g. milk factory and meat processor rather than the 40,000 farmers. This will reduce it to around 300 points of obligation and the processors will average it out across the farmers. It may be possible for farms to claim they are better than average, however this is likely to require a lot of work to prove it. Improving intensity may reduce liability. There is now more of a focus on emission intensity. Emission intensity has been reduced in the sheep sector by over 20% as they have 20 million less sheep but the same amount of lamb produced, while beef cattle have stayed similar. However intensification and dairying has increased nitrous oxide emissions. Generally dairy are responsible for 40-45% of emissions in NZ while beef and sheep are responsible for 55-60%.

NZAGGRC feel the four challenges to reducing GHG's are manipulating rumen function, reducing nitrous oxide emissions from soil, manipulating the rates of soil carbon change and creating tools for farmer's decision making. They do not consider feed additives as a practical option for NZ farmers.

Many of the researchers in NZ felt strongly that many things that had been suggested, are not as good as they are sometimes made out to be and have not always worked (reduced GHG's) when they were tested it in the chambers. They may work on the laboratory level but they need to get it to work at animal level.

They have also compared the three main ways of testing it at animal level; SF6, greenfix and the chambers. They found that SF6 is quite variable and not replicated in chambers. Chambers are more accurate. Since they first installed the chambers they have compared lambs and ewes, grass quality, lactating ewes, cattle and sheep, beef and dairy cattle and they have also undertaken some alpaca work. The greenfix system is more accurate than SF6 but there are issues with some animals going in more regularly than others and concentrates are not used that much in NZ. The way the greenfix system works is it records emissions when the animal puts its head in to eat concentrates.

Cattle respiratory chamber in NZ

Greenfix

Sheep respiratory chamber in NZ

The NZAGGRC feel the main area of research and progress has been with nitrous oxide. Applying nitrification inhibitors can reduce nitrous oxide by up to 70%. It is focused on the product based on dicyandiamide (DCD). It works by holding the nitrogen that is normally leached or emitted in the root zone so that the plant can use it. It does this by slowing the activity of the nitrifying bacteria in the soil that convert ammonium to nitrate. This boosts the N supply to the pasture for plant growth during the growing season. Therefore it not only reduces nitrous oxide emissions, there is also 60% less leaching and 20% more grass. It can work on all nitrogen sources; urine, dung, fertiliser, N fixation and soil N mineralisation. The problem is their performance is uneven across the country as it varies with soil, farm system and climate (it breaks down at 12˚C). It is advised to apply in April when soil temperature is 15^{O}C and falling within 7 days after grazing and ensure the treated areas receive 10mm of rain or irrigation prior to the next grazing. The second application is advised in mid-July (within 3.5 months of the first application). The use of nitrification inhibitor is not considered economically viable for sheep and beef or deer farmers but is a promising option for dairy farms in suitable areas. They are an effective tool for managing the conversion of ammonium to nitrate, significantly reducing nitrous oxide emissions and nitrate leaching. The effectiveness of the inhibitors depends on temperature, rainfall, drainage, aeration, and nutrient holding characteristics of the soils. Increased stocking rates also affect it due to increases in the number of urine patches. Timing of application is also important. It must be applied 7 days before grazing. There are two ways of applying DCD; as a fine spray or fertiliser containing DCD. Applying with a fine spray provides better coverage and is therefore more effective than including in a fertiliser. Including it in fertiliser leaves spaces between the pellets where urine is likely to be deposited. Urine is the primary source for N losses, not fertiliser N. Applied by spray it has shown to decrease the amount of nitrate lost from the soil by leaching 10-30% in warmer wetter areas (North Island) and 25-40% in cooler drier areas (South Island). It is calculated that it will decrease nitrous oxide emissions 30-50% per hectare per year. There must be benefits to the farmer before they will use them. Research has shown that there is between 10-20% increased grass growth. Temperature and moisture are the two key factors affecting the extent of the benefits. It also improves the efficiency of nutrient utilisation in the soil, this includes a reduction in the loss of K, Mg and Ca.

The next biggest break through in reducing GHG emissions has been finding low and high methane emitting sheep. A flock of high and low emitting sheep with a mean difference in methane emissions of 7.8% has been identified through screening a selection of industry selected recorded sheep. Screening was carried out over 4 years to eventually screen 1,000+ sheep. Further research has confirmed the consistency of this difference across different diets (pasture through to concentrate pellets) with the differences tending to be greatest under concentrate diets. These ewes have been mated with low and high emitting rams and they are investigating the results further with the offspring. There is 9-40% difference in animals when management and feed are controlled. These animals have been genotyped to screen for genetic markers that could help rapidly identify low emitting animals. However heritability has a low value. They are planning on linking this information to the central progeny test. They also hope to create chambers to measure animals out on-farm. They won't be as accurate as the chambers in the labs, however they will give a good indication.

They have also found variation in pasture (high sugar grass and brassicas up to 20% lower emissions than perennial ryegrass-based pasture). Both white clover and chicory have proved inconsistent at reducing methane yields in comparison with pasture.

Some progress has been made in terms of investigating possible nutritional mechanisms which may influence methane emissions, such as rumen pH and rumen turnover. However, this has been hampered by a lack of difference in methane emissions between white clover or chicory and pasture, and technical difficulties in trying to manipulate these rumen processes without a confounding effect on feed intake.

Scientists are also investigating impermeable covers for effluent storage ponds for biogas production. Methane bio-digesters for anaerobic animal waste ponds.

Algal additives have been investigated as a novel approach to the mitigation of methane due to their high lipid content. They are fed to animals and should theoretically suppress methanogen activity. Results from in-vitro studies showed that the algal species tested had insufficient lipid levels to reduce methane effectively, therefore they were not tested at the next level. However, algal species from other sources have been collected and initial laboratory level studies are looking promising.

NZ scientists are also working on vaccines and inhibitory compounds to raise antibodies in animals against the gut bacteria that produce the methane in order to reduce the methane produced and emitted. Many trials have attempted the ecological approach to changing the rumen microbe population so that less methane is produced. Homoacetogenic bacteria are alternative users of hydrogen to methanogens and could, if conditions are favourable, take roles of methanogens and convert hydrogen to acetate – an energy source for the ruminant instead of methane. The question is if this is successful how much will the vaccine cost and will it be economical for farmers to use.

NZAGRC funding has allowed two more methanogen genomes to be sequenced and undertaking a detailed study of 10 enzymes produced by methanogens. This information will be used to identify more/better targets for vaccines and to design or identify chemical compounds that could suppress methanogen growth. This is still at the stage where testing is in the laboratory and not at the animal stage. Again, the question is if this is proved to be a successful approach to reducing GHG emissions how much will the vaccine cost and will it be worthwhile.

NZ scientists are also trying to better quantify how soil water content and soil physical conditions influence nitrous oxide emissions, to inform animal management. This also provides data for the farm system model predictions.

Even though most nitrous oxide emissions come from soil, in some circumstances emissions seem to come from plants themselves. This is being investigated further to see if it is an important emissions pathway.

Tests of the efficacy of nitrification inhibitors have focused on the timing of application and the implications of soil pore space and animal trampling. Initial results indicate that high efficacy could potentially be obtained with a single, winter application regime. Animal trampling was found to have a critical impact on the absolute quantity of nitrous oxide emitted but nitrification inhibitors were found to work equally well on trampled and non-trampled soils.

Most nitrous oxide emissions in NZ come from urine patches excreted onto soil from the animal. One project looked at whether diluting the concentration of nitrogen in animal urine (e.g. by feeding a diuretic) could reduce emissions. Early results suggest that varying the concentration of nitrogen in animal urine over a normal range does not affect nitrous oxide emissions.

NZ scientists have also investigated increasing the quantity of carbon stored in agricultural soils. Maximum storage potential depends on climate and soil characteristics. Research is focusing on; the replacement of conventional grassland with deep-rooting species; the introduction of earthworms; and the production and addition of biochar. Biochar is charcoal created by the pyrolysis of biomass under carefully controlled conditions. It is intended to be added to soils to improve soil functions and to reduce emissions from the organic material that would otherwise naturally degrade to carbon dioxide. NZAGRC research focuses on the use of biochar in pasture soils to promote deep root growth and on the development of robust methodologies for monitoring its impacts on soil carbon and organic matter.

Many of these are in the early stages of development and it is likely to be a few years (maybe 5-10 years) before we see many of the above on a commercial scale.

It has been calculated that 1 kg of NZ lamb meat produces 19kg CO_2. As previously mentioned it has been calculated that the NZ lamb life cycle carbon footprint is 3% from meat processing, 5% from all transportation, 12% from consumer phase and 80% on farm. Therefore 15.2 kg (of the 19kg) CO_2 is produced on-farm.

How to achieve reductions

More productive systems to reduce emissions per kg meat produced:

1. Increase output per animal (multiples)
2. Improve number of animals reared
3. Improve growth rates (reduce time to slaughter) preferably with less feed
4. Achieve higher yields
5. Increase length of productive life
6. Reduce disease incidence which impacts on several of the above

What could I possibly do from what I have learnt?

The climate is more stock friendly in Australia and New Zealand than the UK (less dependant on supplementary feeding with grass growth throughout the winter months and animal health e.g. Nematodirus only occurs in the very South of NZ where the climate is more like the UK). The scale of farming enterprises and regulations in Australia and New Zealand are very different making many options difficult to apply in the Welsh upland environment. However there were a number of things that I felt that are needed to be implemented in the Welsh beef and sheep industry. The main point would be to expand the farm size, (increase acreage and stock numbers) to justify equipment and improve efficiency.

- Improve handling facilities to improve animal welfare and reduce labour.
- Keep more records (DLWG, lambing etc) to have the information available in order to choose and keep the most productive animals in the flock.
- Shear some smaller ram lambs June/July as well as ewe lambs to improve growth rates if weather permits
- Continue to increase weaning percentage to increase output per animal.

Other ideas for Welsh farmers that are not suitable for the system on our farm or practices we are already using on our farm:

- Plant more forage crops to reduce dependence on purchased feed and improve the taste of lamb.
- Mob grazing and move sheep more regularly to improve utilisation of grassland and improve animal health.
- Winter shearing to increase forage intakes and reduce concentrates.
- Breed for worm resilience not resistance.
- Sell/buy rams earlier in the breeding season to allow them to adjust to the farm before they are needed.
- Sell lambs before winter – there is a reason why not finished by this point and they would probably be better off finished elsewhere.
- Performance recording to breed from efficient animals.