Mitigation Advice

Introduction

Mitigating greenhouse gas (GHG) emissions makes business sense. However, as an industry we will be required by international agreements to reduce GHG emissions - the Government is seeking national emission cuts across all sectors of 18 per cent from 2008 levels by 2020. Reaching these targets is currently voluntary. The CLA, together with the NFU and AIC, have produced an outline plan of how over time this will be achieved within the agriculture sector. This action plan was published on 10 February 2010.

At present agriculture in the UK produces about **7 percent** of UK greenhouse gases. Within this about:

- 50 percent are nitrous oxide from the soil, much of it an inevitable part of using fertilisers, organic or mineral,
- 40 percent is methane, mainly from livestock and some from manure and slurry and
- 10 percent is carbon dioxide, from energy use by vehicles, machinery, heating and so on.

If the land-use sector can voluntarily meet the Government targets for GHG emissions it will be in a strong position to avoid further regulation. Additionally, as a value is put upon carbon and carbon trading becomes more established, there will be increasing opportunities for landowners to profit from carbon sequestration.

The CALM calculator is designed to look specifically at the emissions produced directly by the *activities* of the farm or estate using the same method as used to prepare the national inventory. This has the advantage of showing the impact of any government policy designed to reduce emission from the farm sector and ensures that there is no double counting of the sectors' emissions. Unlike *product*-based life-cycle analysis, it takes no account of emissions produced upstream or downstream of the farm (for example the carbon balance of manufacturing fertiliser).

There are a number of common themes to GHG reduction:

- Inputs should be used more efficiently (e.g. nitrogen fertiliser and fuel)

- For livestock based enterprises, a reduction generally means the minimisation of the non-productive period and maximising production per animal. Thus, emissions associated with dairy production relate to the number of stock involved so a reduction requires maximisation of the milk production per head (unless this is only achieved by feeding high emission inputs). In turn, this means minimising the number of unproductive young-stock replacements by reducing age at calving and increasing the productive period for the milking herd.

- There are a few actions that will decrease emissions but will not at present make a change to the national inventory. However, improving the sophistication of the calculation is a government objective. Thus there is a genetic component of livestock methane emissions and while the national average may change the impact of individual breeding advances are unlikely to impact on the national inventory in the short term.

- Inputs can be sourced more efficiently such as purchase or generation of "green electricity" or other biofuels or purchase fertiliser with a low input of fossil fuel in its manufacture (much of the fertiliser used in the UK actually has a very low carbon content because it is manufactured using hydroelectric power).

- Planting grass on arable land or planting trees will capture carbon but have an impact on production. Whether it is worthwhile depends on how society values carbon saving against food production but there are areas on many farms where land is relatively unproductive, and unprofitable, where grass margins or small woodland coppices may capture carbon and create extra value for the business. This also achieves other environmental objectives for wildlife and lanscape and ties in with government run agri-environment schemes.

Most reductions in GHG also result in a saving in cost because inputs are used more efficiently. By looking at inputs in a different way, it is common to find that a GHG calculation results in cost savings which would not have been revealed in other ways.

There is often a trade-off between production and emissions. Clearly if production ceases so does the level of emissions. However, extensification will also often reduce emissions so, for example, a reduction in stocking rate leading to an increase in grass area may result in net greenhouse capture.

Energy

It is estimated that energy savings of up to 20% across the agricultural and horticultural sector are possible totalling over £40 million each year (Carbon Trust). Energy is used in many ways, from drying of cereal crops and cooling of milk, to the heating and ventilation of livestock buildings and glasshouses. The biggest areas of energy saving potential are field operations (nearly 50% of energy used), heating (over 25%), refrigeration (about 15%), lighting (about 10%) and ventilation (about 5%).

Saving energy brings the following advantages:

General

Carbon dioxide (CO_2) is released by burning fossil fuels e.g. fuel in tractors, farm vehicles and machinery, and fuel for heating buildings. These emissions are often low compared to other emissions on the farm i.e. from livestock and nitrogen fertiliser use where methane and nitrous oxide are the greenhouse gases (GHGs) involved.

Fuel efficiency can be improved for tractors and farm vehicles by:

- Reducing distance travelled by being more efficient with journeys
- Turning off engines when not in use
- Regular servicing of tractors and engines to ensure engines are running to maximum efficiency
- Checking tyre pressures to ensure that farm vehicles, tractors and machinery are working to their optimum efficiency
- Reducing cultivation depth to reduce the energy required to move soil
- Ensuring tractors are properly weighted to minimize tyre slippage
- Choosing tractor horsepower to match the task being undertaken i.e. by avoiding use of over - large tractors and matching implement width to tractor size.

Consider low-carbon transport fuels for farm machinery (e.g. biodiesel). Biofuels may reduce GHG emissions by over 50% when compared to fossil fuels.

Energy efficiency for buildings can be improved by:

- Ensuring optimum insulation levels to minimise heat transfer (both in and out)
- Using draft curtains and draft proofing for buildings that require space heating
- Installing energy control systems on all heating and drying equipment, and where appropriate relative humidity controls
- Avoiding over drying (or cooling) of crop

Check that the buyer needs crop at the moisture content historically specified. Buyers of crop are increasing looking at energy saving within the supply chain and may be receptive to change.

Electricity

Carbon dioxide (CO_2) is released as an indirect emission when electricity is used, i.e. it is emitted in the production of electricity rather than directly on the farm. Electricity use on the farm is usually relatively small unless used for crop drying or refrigeration

Electricity use may be reduced by:

- Switching off equipment when not in use (i.e. not leaving on stand-by)

- Using timers and movement detectors for energy and lighting control
- Replacing equipment with energy efficient appliances
- Setting thermostats and controllers at the most appropriate level and lowering working temperature if appropriate (make sure that air conditioning and heating systems do not overlap on the transition range to act in opposition)
- Keeping all equipment (especially electric motors) clean
- Considering joining the Climate Change Levy Scheme (for pig, poultry or horticulture producers). This scheme enables producers to claim a rebate in return for meeting energy saving targets
- Considering more efficient systems especially for heating including renewable heat from biomass
- Installing energy saving controls on fans and heating equipment (e.g. timers and humidity controls) for crop drying

GHG emissions may be reduced by changing energy supplier. A number of electricity suppliers will supply electricity with a high renewable content for little or no additional premium or supply 100% renewable electricity for a small price premium.

Biofuels

Renewable heat is often an effective way to reduce GHG emissions.

Biomass boilers can use waste wood from woodland, or energy crops such as short rotation coppice and Miscanthus, or agricultural residues to supply heat. Supply of heat may not be restricted to the farm or estate property but may be sold to other business or residences on the holding.

Farms and estates may also grow crops to provide a supply of renewable energy to others to burn.

Anaerobic digestion to produce electricity and/or heat is an important option for businesses with high levels of organic waste such as vegetable packers or livestock units.

Renewable transport fuels such as biodiesel and/or bioethanol also reduce emissions. Production of small quantities of biodiesel on farm by processing waste vegetable oils from local food businesses, or (less profitably) by using own oilseed rape grown on the farm. (See the CLA Biomass Energy Handbook available from the CLA website).

There are a number of grants and incentives available.

A new feed-in tariff introduced from 1 April 2010 for electricity will make a number of renewable energy schemes commercially viable that were not so before, perhaps because of the seasonal nature of the farm demand. For example, mini wind turbines are now economically viable in a number of areas for grain conditioning or management of seasonal cold stores, where in the off-season the surplus electricity generated can be sold (fed-in) to the National Grid at a guaranteed price.

Farm energy production may not only be profitable in its own right and reduce GHG emissions but also helps to safeguard the business against rising energy costs.

NB: CALM currently scores the use of renewable energy as having zero emissions, in line with the national inventory methodology. Defra is currently reviewing this as the real emissions of producing renewables can be greater than zero. The calculator will be updated as necessary.

Fertiliser and Manure (nitrogen)

Spreading manufactured nitrogen fertiliser and manures releases nitrous oxide (N_2O) a powerful greenhouse gas. Nitrous Oxide (N_2O) has around 310 times the greenhouse effect of carbon dioxide (CO_2), so even small applications are likely to produce emissions which will contribute a significant part of your GHG emission.

In order to reduce emissions the total quantity of nitrogen applied needs to be reduced by increasing the efficiency of application by reducing waste. Efficient and effective use of N can be maximised by:

- Adjusting total N application to match crop demand taking into account soil analysis, the nutrient value of any organic manures and by using a proven system such as RB209 or PLANET (Planning Land Applications of Nutrients for Efficiency and the Environment).
- Maintaining and checking calibration of fertiliser and manure spreaders
- Minimising run-off such as may occur when applied to frozen or to sloping land prior to rain, or by injecting manures.
- Applying smaller quantities of fertiliser at each application time, using precision farming technology
- Minimising application in water-logged conditions
- Applying when the crop or grass is able to make efficient use of the fertiliser or manure applied (i.e. when it is growing (i.e. not in the winter) and ideally, when there is good cover). However, there is a balance since in cold weather less ammonia is converted to nitrate reducing emissions.

Nitrogen in manures may be reduced by adjusting nitrogen in diets to more accurately reflect dietary requirement.

Lime

The emissions from limestone and chalk will be similar but the emissions from dolomite will be slightly higher due to the presence of magnesium. It is assumed all the carbon contained in these materials is released in the year of use.

Check that the soil is properly mapped, that application matches the analysis for the soil type and that quantities of lime delivered are as expected.

Livestock

Livestock are responsible for the majority of methane emissions from agriculture and some of the nitrous oxide. Methane (CH_4) contributes 21 times more to global warming than the equivalent quantity of carbon dioxide and nitrous oxide (N_2O) is 310 times more potent. This means that small reductions in these GHG emissions will have a large positive impact on your CALM balance.

The majority of CH_4 emissions from ruminant livestock are from enteric fermentation, the fermentation that takes place in the digestive system of ruminant animals. The process converts otherwise unusable plant materials into food and fibre, and releases CH_4 in the process. Cattle are the most significant emitters, making up one third of UK total methane emissions. The manures are also an important source of both methane and nitrous oxide. Consequently, the management of livestock manures is an important factor when thinking about reducing GHG emissions.

Methane emissions

There are relatively few ways to reduce CH_4 emissions from livestock. The most effective means of reducing emissions is to reduce the unproductive period or maximise the production per emitter (i.e. milk yield per cow). To reduce CH_4 production:

- Reduce calving index
- Reduce number of breeding stock replacements
  - Increase productive life of producing stock
  - Reduce age that animals enter the breeding herd
  - Increase fertility
- Increase yield of outputs (milk, young-stock, eggs, etc.)
- Maximise growth rates to reduce age at finishing and minimise fat content of animals for meat.
- Taylor diets to the animals' need. Diet can impact on emissions by up to 40%. Diet supplements can also be introduced to reduce emissions.

There is considerable genetic variation and breeding programmes are likely to include this aspect in future. Research is ongoing into new forage and grazing mixes to reduce emissions.

Manure storage system has a large impact on methane emission with wet systems (i.e. slurry) producing the highest emissions. Anaerobic Digestion increases methane production from the manure by controlling the environment and then converts the methane to carbon dioxide (equivalent to the carbon dioxide taken out of the air in the feed consumed) and produces energy substituting for fossil fuel. Grant aid and a price premium for the electricity (through feed in tariffs or renewable energy certificates (ROCs)) is available. Inclusion of waste food or vegetable waste will increase the amount of gas produced.

Nitrous oxide emissions

See section on “Fertiliser and Manure”.

Crops and grass

The yield of the harvested crop is used to calculate the N_2O emissions from the crop residues. When crop residues are ploughed into the soil some of the N contained in the residue is emitted as N_2O. In addition, some of the nitrogen fixed by legumes is released into the soil and released as N_2O.

The contribution of the N_2O released by legumes to the national inventory for agriculture is less than 1% (because the area is small) but the contribution from crop residues can be up to 10%. The best approach to mitigating N_2O emissions is to be efficient with the supply of nitrogen to the crop and adjusting the nitrogen applied (either from organic or inorganic sources) to the crop requirement.

When land is converted to grass the cessation of annual cultivation results in a lower rate of oxidation and in the first few years (CALM considers that the gain occurs in the first year) the permanent extra above and below ground plant matter achieves a once off gain in carbon over an annual crop that decays each year. Crops such as Miscanthus achieve a similar gain to grass.

Land use change

The Land Use Change component of the CALM calculation measures the release or gain in soil carbon resulting in the change of land use between arable, grass and woodland (order of increasing soil carbon). Under each of these land uses, a carbon equilibrium is reached resulting from a balance between the rate of oxidation of soil carbon reserves to carbon dioxide (largely dependent on cultivation and moisture) and the gain in soil organic matter produced by the vegetation.

It is estimated that increases in soil carbon take between 100 and 300 years while a reduction in soil carbon takes around 100 years. However, there is enormous variation between soil types and geographical area since factors such as temperature, rainfall, slope, shading and water logging can exert a large influence. Most of the changes occur in the early stages of the change and CALM takes into account only this period of greatest change.

Cultivation system does not have a consistent affect on soil emissions since if it results in marginally higher moisture content, the production of nitrous oxide increases. Since nitrous oxide has a global warming potential of around 310 times higher than carbon dioxide the increase in carbon saving can have a small impact compared with the release of extra nitrous oxide. In addition, any extra carbon capture could easily be lost if other cultivations systems are used within the rotation. However, in some areas of the US min-till is an accepted means of increasing the carbon in the soil where it is practiced continually. Reduced cultivation may become accepted in the UK in some circumstances in the future, for example, on freely draining soils in dry areas and for crops sown in dry conditions, such as oilseed rape or late sown spring crops. Regardless of this min-till does, of course, reduce the energy required to establish the crop.

Annual applications of organic manures, mulches, composts and materials such as biochar are likely to increase soil carbon reserves although manures at least also produce high nitrous oxide emissions.

CALM also includes a one-year gain where arable land is returned to grass to reflect the one-off gain in the perennial grass matter. This one- off gain would also apply to (most) other perennial crops.

Soil carbon has a big impact on greenhouse gas emission and further study is likely to be a research priority.

Environmental Stewardship

Grass field margins in arable fields and buffer strips such as under cross compliance or Entry Level Stewardship scheme options will capture carbon annually over a long period in addition to the one-off gain. Almost any perennial crop will also have a positive impact.

The calculator now includes an estimate of the GHG saving from the government Entry Level (ELS) and Higher Level (HLS) Stewardship schemes. The saving is calculated as a partial budget to estimate what would be saved following entry into Stewardship or what has been saved where the business is already in the scheme. The calculation should be relative to the whole business calculation (which should be completed first). It is not a measure of carbon capture (sequestration) but the annual change in emission pre and post entry, although some of the changes, such as new grass margins on arable land do sequester carbon (where they remain in place).

Organic soil (peat/fens)

Peatlands are thought to be the UK's largest carbon store holding more carbon than all the forests of Britain and France. The main threat is drainage which can have a dramatic effect on the carbon dioxide released (as illustrated by drops in soil level by nearly 2m in parts of the fens), although any erosion or damage can lead to a large emission.

Since these soils are some of the most productive in the country it is unlikely that there would be any enthusiasm to re-flood drained areas or even re-grass land that is now in arable production.

Woodland and carbon sequestration

Trees absorb carbon dioxide through photosynthesis converting the carbon dioxide into woody biomass. This is known as "carbon sequestration". It is a dynamic process in which carbon is continually exchanged between the atmosphere and the trees. Over the lifetime of the tree more carbon is captured than is released so there is net accumulation in the forest. Carbon is only accumulated up to the point in the life of the forest when equilibrium is reached, and therefore the quantity of carbon accumulated is finite.

The rate of sequestration is slow during the early phase of forest establishment, increasing through the full-vigour growing years, then slowing as the forest reaches maturity and equilibrium. Fast-growing stands in the UK can typically sequester 36t CO_2e/ha/yr although over a full commercial rotation this is more likely to average 11t CO_2e/ha/yr.

Forest soils may contain more carbon than the trees themselves. The quantity will depend on the inherent carbon content of the original soil before planting plus that sequestered by the growing forest. Typical UK forest soil values range between 800-2200 t CO_2e/ha; arable soils by comparison will typically contain 550t CO_2e/ha.

- Plant new forests and farm woodlands with higher yielding, long-lived species
- Avoid planting on organic peaty soils.
- Where possible plant close to the markets and population centres to reduce transport of the timber, for fuel and construction
- Maximise production potential by minimising losses by fire, wind-blow and pests (such as by managing deer populations to improve natural regeneration).
- Increase productivity by improved thinning practice, using thinnings for energy, minimising fuel use in harvesting, and minimizing soil disturbance.
- Consider alternative methods of forest management such as continuous cover instead of plantation clear-cut, this is a more natural and complex ecosystems which may better adapt to climate change.

Other Points

There are a number of areas that the calculator does not specifically handle but can with careful use be used to estimate.

There is no significant annual gain in carbon per year from a mature hedgerow or orchard since the new growth is largely periodically removed to decay. There clearly is a gain where hedgerows or orchards are planted up until they reach maturity. Most hedgerow options would have a beneficial effect on emissions, because of increased biomass in the hedge and lower fuel consumption owing to less frequent cutting. However, at present, the increased biomass does not contribute to the inventory in the agreed standards and therefore we have omitted this from the calculation.

Sources of other information:

CLA, NFU and AIC report on climate change mitigation, **Agriculture Industry GHG Action Plan: Framework for Action** available on the CLA website at www.cla.org.uk/Policy_Work/Environment/

Carbon Trust at www.CarbonTrust.co.uk

Farming Futures at www.farmingfutures.org.uk

Advice on energy efficiency also available at http://www.energysavingtrust.org.uk/

The Biomass Energy handbook from the CLA. Telephone: 020 7235 0511.

Climate Change Levy Scheme at

http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_ShowContent&id=HMCE_PROD_009791&propertyType=document

Biofuel efficiency: http://statistics.defra.gov.uk/esg/conference/aes2007/NigelMortimer.pdf

IGER report "a review of research to identify best practice for reducing GHGs form agriculture and land management". Available on the Defra website as project number AC0206 http://randd.defra.gov.uk/

PLANET website at http://www.planet4farmers.co.uk

FACTs website at http://www.factsinfo.org.uk/facts/

Defra Farm Woodland Grant Scheme at http://www.defra.gov.uk/erdp/schemes/wgs

Forestry Commission at www.forestry.gov.uk