Net zero in agriculture

The UK government has legislated a target of net zero GHG emissions by 2050, recognising the importance of tackling climate change. Agriculture contributed around 11% of the total UK greenhouse gas (GHG) emissions in 2019. Unlike many other sectors' emissions that are dominated by carbon dioxide (CO_2), agricultural emissions are dominated by gases such as methane (CH_4) and nitrous oxide (N_2O). These gases are emitted through the biological activity of organisms as they break down nutrients e.g. enteric fermentation in the rumen of cattle and sheep, and bacteria in the soil. The overuse of fertilisers, misuse of soils and reduction in methane- and carbon- absorbing ecosystems is resulting in GHG emissions beyond their natural levels. In this article we will provide some information on what net zero in agriculture means, and actions that can be introduced on farm to help reduce GHG emissions.

What is net zero?

Net zero refers to the balance between all GHG **emissions produced** and **the removal of CO_2** from the atmosphere, predominantly by sequestering carbon into trees, plants and small amounts within soils over an extended length of time.

Achieving net zero is one of the Government's top priorities, with a particular focus on 2021 as the UK hosted both the G7 summit and COP26[1]. Pressure to achieve net zero comes both from international agreements such as the United Nation's Framework Convention on Climate Change's Paris Agreement[2], the UK's own legislation within the Climate Change Act, internal advisory committees like the UK Committee on Climate Change[3] and industry. Further detail on these policy drivers can be found in Annex 1. For the UK to meet this economy-wide target, all sectors need to contribute further emission reductions. Agriculture and land use has a particular role to play as it is currently the only economic sector with the opportunity to capture CO_2 from the atmosphere, while reducing its emissions.

[1] International climate change conference organised by the UN
[2] United Nations Framework Convention on Climate Change
[3] United Kingdom Committee on Climate Change

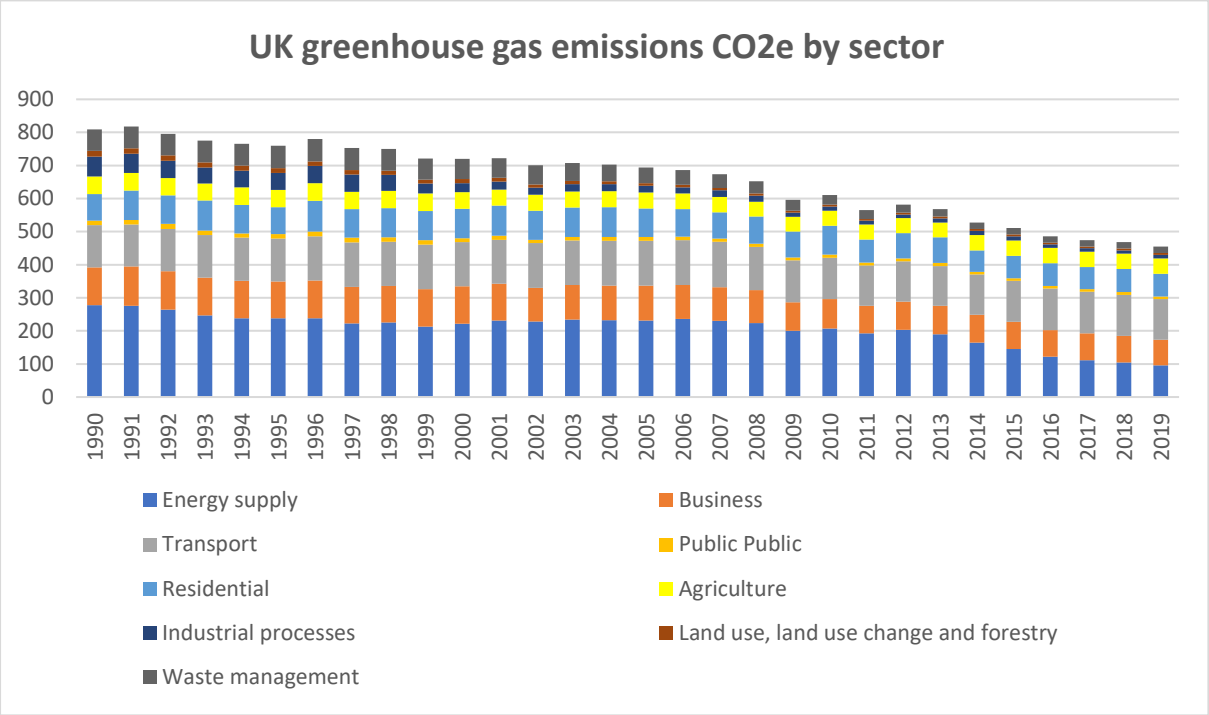

Figure 1: Trends in UK GHG emissions (derived from data.gov.uk)[4]

The UK has reduced its emissions since 1990[5], see Figure 1, but there is still a long way to go. Agriculture, shown in yellow in figure 1, may look like only a small part of the but it is important to understand this in context:

- After an initial reduction in emissions, principally due to falling livestock numbers, agricultural emissions have been increasing since 2009.
- The 13% reduction in agricultural emissions since 1990 is small compared with the reductions in other sectors such as energy (66%), industry (83%) and waste (71%)[4].
- Agricultural emissions are different from other sectors as CO_2 is not the principal concern. In 2019 agriculture was responsible for 68% of nitrous oxide (N_2O) emissions, 47% of total methane (CH_4) emissions, and 1.7% of carbon dioxide (CO_2) emissions in the UK[6]. The sources of these emissions in 2019 can be seen in Figure 2. All countries report their emissions using the same guidance and figure 2 uses the IPCC headings. If you would like to find out more about what makes up the different groupings, have a look at the IPCC's guidance notes which you can access here.

[4] Final UK greenhouse gas emissions national statistics - data.gov.uk (last updated 24 June 2021)
[5] The internationally agreed baseline
[6] DEFRA (2021) Agri-climate report 2021 - GOV.UK (www.gov.uk)

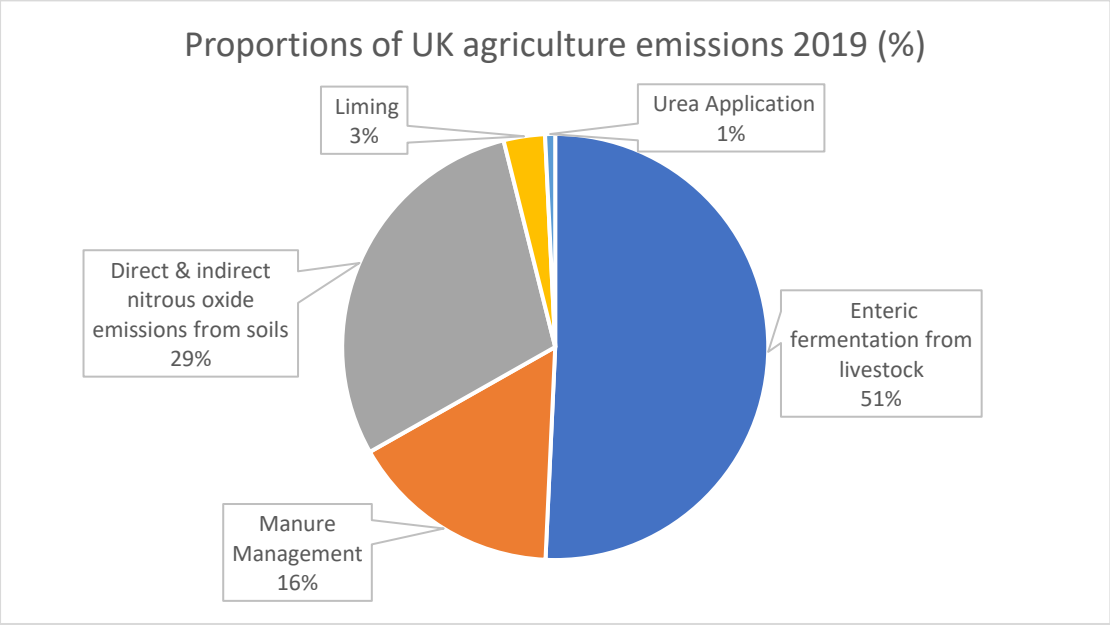

Figure 2: 2019 UK agriculture emissions by source (%)[7]

The sources of emissions in agriculture in 2019 can be seen in Figure 2. All countries report their emissions using the same guidance and figure 2 uses the IPCC headings. If you would like to find out more about what makes up the different groupings, have a look at the IPCC's guidance notes which you can access here.

To make it easier to compare different gases locally and internationally, GHGs are reduced to a CO_2 equivalent or CO_2e. To work this out, the warming effect of each gas is compared to the warming effect of CO_2 over 100 years, producing a Global Warming Potential or GWP. CH_4 and N_2O have a greater warming impact that CO_2, thus a higher GWP. These are shown in Table 1 along with their agricultural sources.

Table 1: Examples of sources of GHG emissions in agriculture.

GHG and GWP	Example of a source in agriculture	Example of a process creating the GHG
Methane (CH_4) GWP: 25-28	Enteric fermentation	During the digestion process of ruminants (e.g. cattle), CH_4 is released, mainly through belching.
	Manure management	CH_4 is released from livestock manure when it breaks down in anaerobic conditions (without oxygen).
Nitrous oxide (N_2O) GWP: 265-298	Manure management	N_2O is released through the nitrification-denitrification of nitrogen in livestock manure.
	Soil management	N_2O is released during the breakdown of synthetic fertilisers applied to land. N_2O is naturally produced in soils, but applying fertiliser dramatically increases emissions.
Carbon dioxide (CO_2) GWP: 1	Liming	Adding lime to agricultural soils helps to reduce soil acidification. If the lime comes into contact with strong acidic sources in the soil, the reaction releases CO_2.

[7] Data - NAEI, UK (beis.gov.uk)

	Stationary and mobile machinery	Engine combustion while machinery is in use or stationary produces CO_2.
	Land use change	Converting woodland (carbon sink) into intensively farmed fields (carbon source).

GHG tools

Using GHG auditing tools (also referred to as carbon audits) on your farm is a first step in understanding where the GHGs are coming from, allowing you to identify actions to reduce emissions. Championing the Farmed Environment (CFE) has put together a handy guide comparing some of the common GHG auditing tools and a table with the information needed to start an audit. Access it here.

Of course, emissions are only half of the story. Farmers and land managers also have the opportunity to sequester carbon in trees, biomass and small amounts within soils over an extended length of time. Reducing emissions on farm while increasing opportunities for sequestration is the two-pronged approach we need to tackle climate change. The CFE website has blog posts, podcasts and handy guides for more information.

This table provides an overview of some of the actions that can be reduce GHG emissions on your farm. It should be noted that each will have trade-offs and costs that should be carefully considered. Some actions will show immediate results in your costs and emissions, while others may take years to develop.

Table 2. Examples of GHG mitigation actions that can be implemented on farms and the associated benefits to a business and the environment.

Target area	Mitigation action	Benefit to your business	Benefits to the environment
Nutrient management (all farming sectors)	Nutrient management plans: assess current usage and needs and plan to match these. This applies to animal feed, inorganic and organic fertiliser use.	Better planning improves your business's long term resilience and ability to forecast cashflow needs.	Planning nutrient applications and matching inputs to the crop needs mitigates the risk of overapplying Nitrogen on the ground, reducing GHGs in the form of N2O and reduces risk of pollution through nutrient run-off
	Use low emission spreading techniques	Improved health and safety for your staff and improved relationships with your neighbours	Reducing nutrient surplus will protect soil and water biology, reduce GHG emissions and reduce ammonia emissions and odour, improving local air quality.
	Incorporate manures into soils	Crops have better access to the nutrients, helping to improve yields.	Reduced N_2O emissions, reduces run-off
	Use precision technology: feeding, irrigation, nutrient management etc	Saves labour and input costs, potential for improved live weight gain or crop production.	Reduces waste thus improving water, soil and air biology and reducing GHG emissions
Energy management (all farming sectors)	Ensure all buildings including animal housing, grain dryers, barns, greenhouses etc are fit for purpose and efficient in their energy use. This could be as simple as using LED lighting to more complex heating, cooling and humidity systems involving physical alterations like thermal screens or trees to energy management systems.	Lower energy bills, potentially better animal welfare, higher horticulture growth rates, reduced wear and tear of pumps, engines etc. Improved storeroom functionality can reduce spoilage improving the quality and quantity of your products.	Reduced GHG emissions from lighting, heating and cooling. Using trees around the buildings to increase shade will reduce local ammonia emissions, increase biodiversity habitat, increase carbon sequestration potential, reduce flooding potential.

Energy production	Install renewables such as wind turbines and/or solar panels for the generation of both electricity and heat.	Lower energy bills due to using energy produced onsite. Improved business resilience to changing energy prices. Potential to sell into the grid when surplus to your own needs.	Reduced GHG emissions from fossil fuels used in energy production. Reduced air pollution if the renewables are used to replace on-farm diesel generators, combustion engines and/or drying equipment.
Water management (all farming sectors)	Optimise water use from buildings, water troughs, irrigation and cooling equipment.	Lower risks to buildings and farm infrastructure, potentially lower energy costs, improved animal welfare.	Managed water peaks into local water courses can reduce downstream flooding. Reduced pumping reduces energy associated emissions. Reduced reliance on natural water sources supports biodiversity.
Livestock production	Manure management: introducing covers on stores.	Covers prevent rainwater entering your store, saving costs by reducing the need for more storage.	Covering slurry stores can greatly reduce the ammonia emissions released.
	Excellent livestock health management including a vet approved herd health plan.	Better quality of animal welfare will improve the efficiency of livestock. This includes improved fertility and growth.	Healthier livestock have greater output and therefore better ratio between emissions and output, leading to better GHG emissions per tonne of produce.
	Matching breed specification (size and conformity) to your customer's requirements	Receive a better price, easier to sell.	Reduced waste saves emissions.
	Precision feeding where applicable e.g. match protein in feed with requirements of the animal type and time of production process e.g. lambing, lactation	Production optimisation and potential saving in feed costs	Reduced emissions from ammonia and reduced imported protein
Crop and horticulture production	Reduced tillage	Improved soil resilience and decreased soil erosion. Reduced input costs through reduced labour and fuel and machinery wear.	Using machinery less means lower GHGs and less soil compaction. Less soil compaction allows better water management, less erosion and allows the soil to sequester more carbon (when possible).

	Using cover/catch crops	Improved soil resilience, greater protection against weeds, if using nitrogen fixing crops this reduces the requirement for fertiliser input. Can also provide longer fodder growing seasons allowing for less reliance on bought in feed.	If nitrogen fixing crops are used (like clover), there can be a reduction in the N_2O emissions, an improvement in soil structure and a reduction in CO_2 emissions (from applying fewer inputs). Reduced soil erosion.
	Rotational cropping	Helps plants to become more resilient to drought, flooding and disease reducing demand on irrigation, fertiliser and plant protection products.	Reduced soil erosion, reduced nitrogen fertiliser use if incorporating herbal leys and/or protein crops in the rotation.
	Reduce drainage of peat soils e.g. switch to paludiculture	Meet growing customer demand in an innovative market.	Reduced carbon emissions from peat soils.

Table 3: Useful definitions for net zero in agriculture

GHGs	Greenhouse gases describe gases that warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth.
GHG emissions	Losses of greenhouse gases from human activities. In agriculture, this includes nitrous oxide (N_2O), methane (CH_4) and a smaller amount of carbon dioxide (CO_2).
GHG emissions intensity	GHG emissions per unit of production/output.
GHG removals	The removal of GHGs from the atmosphere through sequestration of CO_2 into carbon biomass, above and below ground e.g. trees or soil, and accumulation of organic matter.
Carbon Stock	The total carbon in biomass and organic matter in carbon stores. This includes, above ground biomass (e.g. woodland, forestry and hedgerows) and below ground biomass/organic matter in soil.
Carbon stock change	Annual changes in carbon stock due to events and activities such as cultivation, tree removal, tree planting, or an increase in biomass and organic matter.
CO2e	Using GWP, greenhouse gases are given an equivalent value to CO2 to provide one total Carbon Dioxide equivalent or CO2e
GWP	Different GHGs have different effects on the Earth's warming due to their ability to absorb energy or "radiative efficiency", and how long they stay in the atmosphere or their "lifetime". The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over 100 years, relative to the emissions of 1 tonne of CO_2. The larger the GWP, the more that gas warms the Earth compared to CO_2 over that time period. GWPs provide a common unit of measure, which allows the compilation of national inventories, and allows policymakers to compare emissions reduction opportunities across sectors and gases.

Table 4: Agriculture policy drivers in England

Policy driver	Description
UNFCCC Paris Agreement	The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP21 in Paris in 2015 and entered into force in 2016. Its goal is to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels.
The Climate Change Act 2008 (2050 Target Amendment) Order 2019	In June 2019, parliament passed legislation requiring the government to reduce the UK's net emissions of greenhouse gases by 100% relative to 1990 levels by 2050.[1] Doing so would make the UK a 'net zero' emitter. Prior to this, the UK was committed to reducing net greenhouse gas emissions by at least 80% of their 1990 levels, also by 2050.
The Agriculture Transition plan (Defra)	In November 2020, the Department for Food, Environment and Rural Affairs (Defra) published the Agricultural transition plan 2021 to 2024. This document outlines the plans for agriculture from 2021 and the policy changes that will be introduced. Actions include the protection of carbon stores, increasing afforestation and peat restoration across England.

Achieving net zero: Farming's 2040 goal (NFU)	In 2019, the NFU published a booklet on its goal to reach net zero in agriculture in England and Wales by 2040. It sets out three target areas: improving farming's productive efficiency, improving land management and changing land use to capture more carbon, and boost renewable energy and the bioeconomy.
Land use: Policies for a Net Zero UK (Committee on Climate Change)	In January 2020, the Committee on Climate Change (CCC) published their advice to the UK government and the devolved nations on agriculture and land use policies in support of net zero targets. The reports set out a range of options to drive emissions reductions • Increase tree planting • Encourage low-carbon farming practices • Restore peatlands • Encourage bioenergy crops • Reduce food waste and consumption of the most carbon-intensive foods
25 Year Environment Plan (Defra)	In November 2018, Defra published its 25 Year Environment Plan. This plan sets out actions to improve England's air and water quality, whilst protecting threatened species of plants, trees and wildlife.