MODULE 4
AIR QUALITY, CLIMATE CHANGE, ENERGY AND WASTE MANAGEMENT

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Air quality

- **Ammonia NH_3+ not a GHG** – Gothenburg Protocol Objectives 2030

- **Methane CH_4** GHG (25 x CO_2) 1kg CH_4 = 25 kg CO_e
- **Nitrous Oxide N_2O** GHG (300 x CO_2) 1kg N_2O = 300kg CO_e
- **Carbon dioxide CO_2** GHG

- **Odour** – nuisance

Carbon dioxide equivalents (CO2e) used to express GHG as above

2

National statistics
Emissions of air pollutants in the UK – Ammonia (NH3)
Updated 19 February 2024

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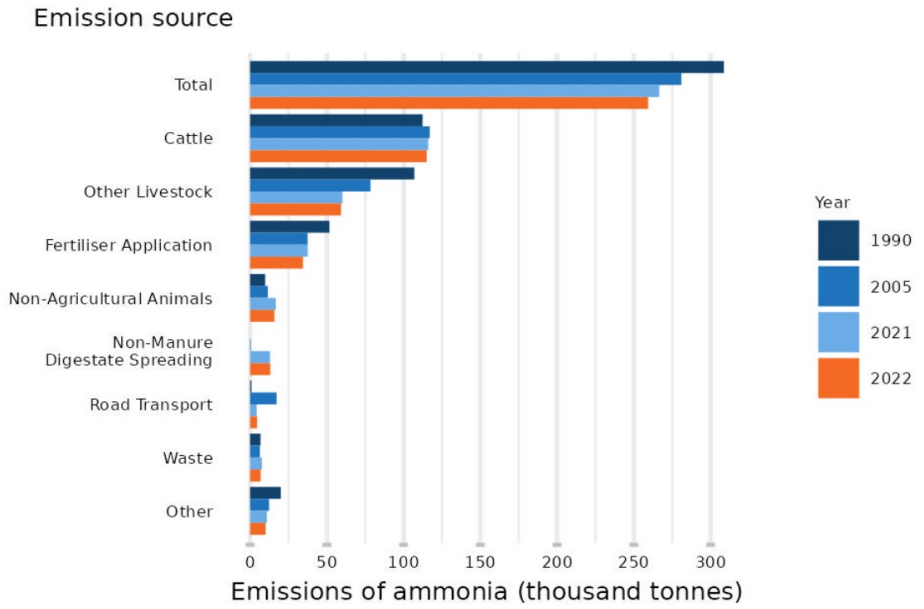

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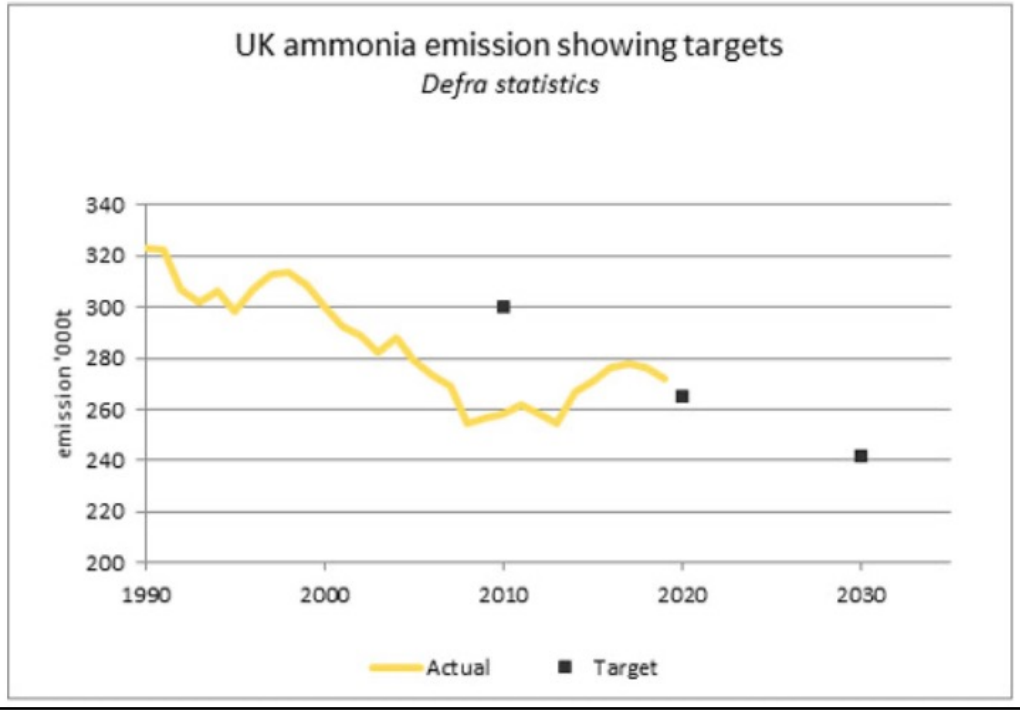

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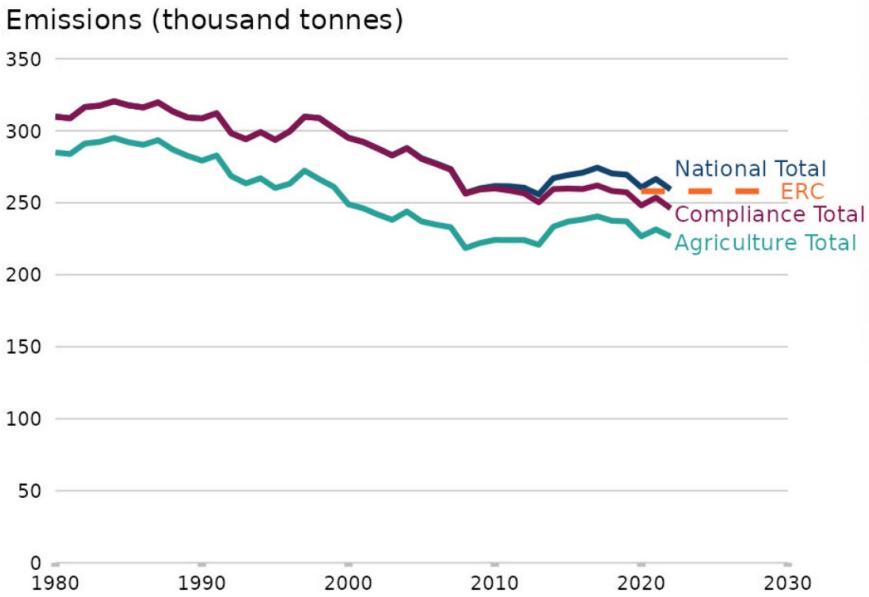

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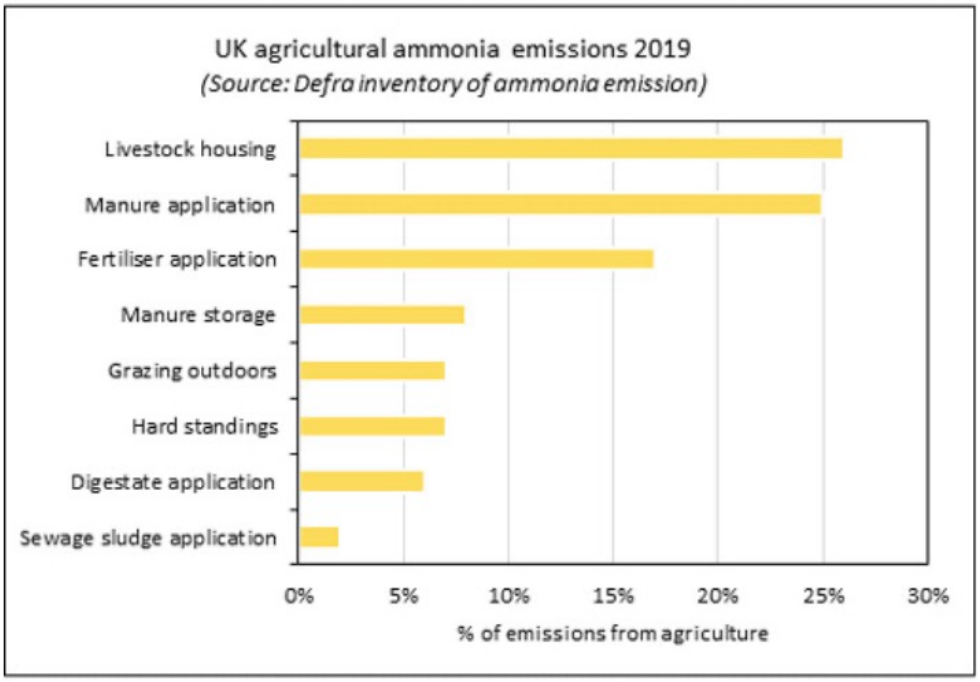

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2019
Livestock housing
followed by
Manure Application
greatest contributor

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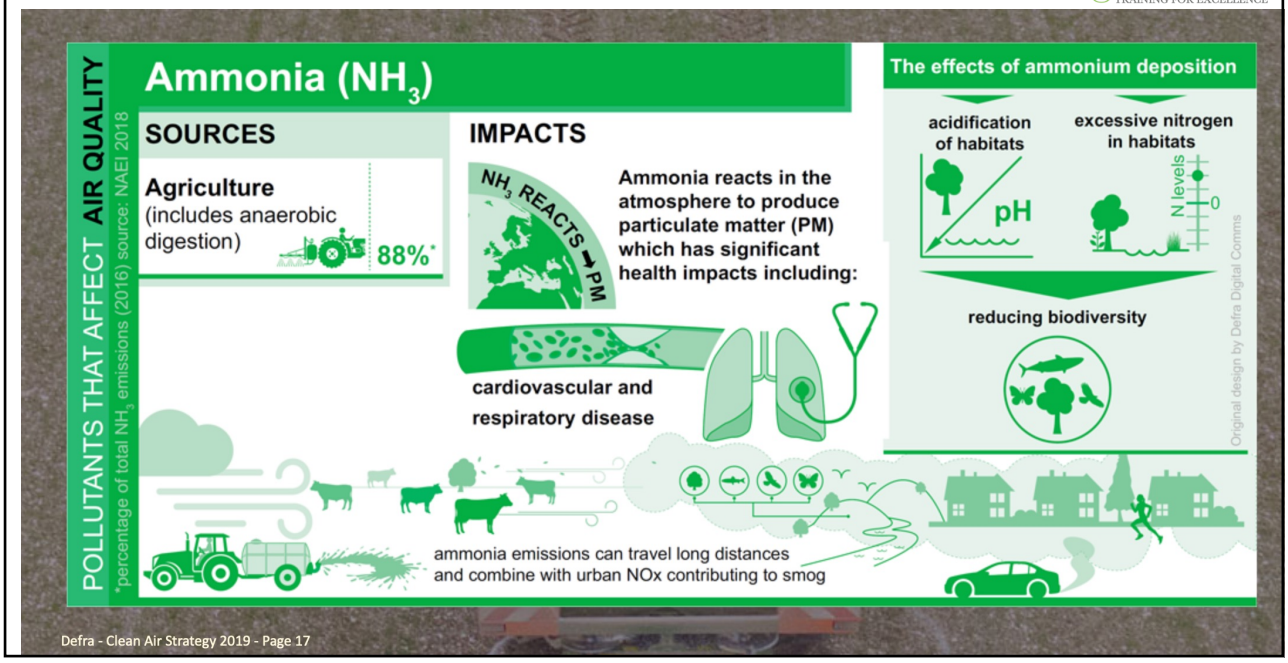

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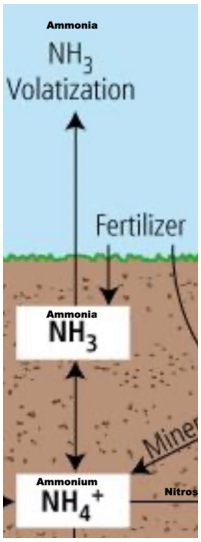
Air Quality

- Agricultural account for around **88%** of **NH3+** emissions.
- High concentrations of **NH3+** in air means N is deposited onto land.
- Damages habitats by changing species of plants present and pollutes streams, rivers and other water bodies.
- **NH3+** can be converted to **N2O** and released from soils.
- Combines with substances in air to form **fine particles**, which harm human health.



RB209 March 2022

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Use of Urea

- **From 1st April 2024**, fertilisers containing urea that are not protected/inhibited can be used only between

15th January and 31st March.

- Outside this window, fertilisers containing urea that are **protected/inhibited** must be used.
- Detailed requirements are to be set out in a **Red Tractor Standard**

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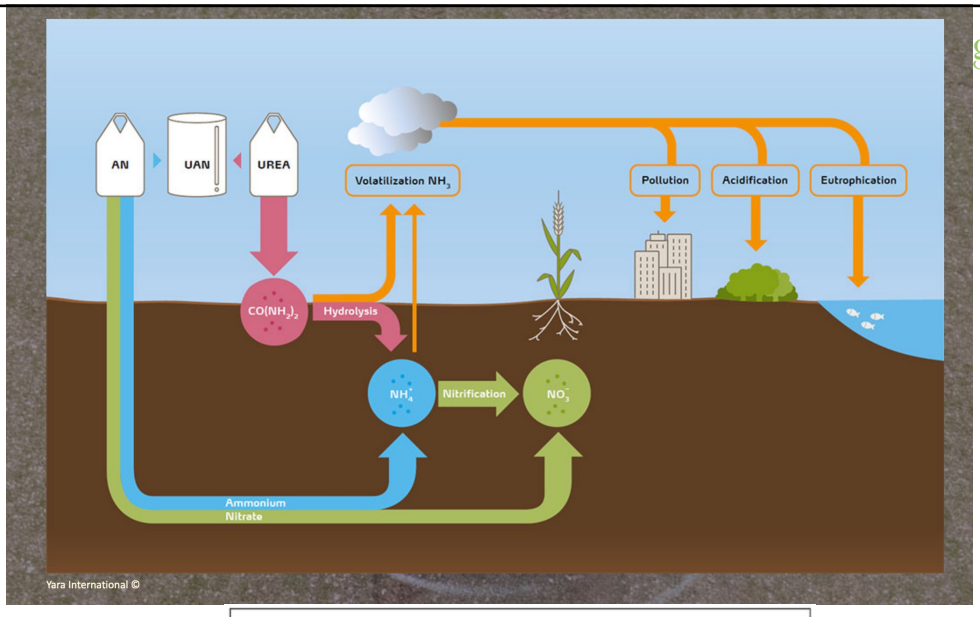

$$CO(NH_2)_2 \text{ (Urea)} + 2H_2O \text{ (Water)} + H^+ \xrightarrow{\text{urease}} 2NH_4^+ \text{ (Ammonium)} + HCO_3^- \text{ (Bicarbonate)}$$

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Mitigate Ammonia NH_3+ emissions

- Apply protected/inhibited fertilisers if they contain urea - < 70%
- Covers on slurry stores - < 80% for rigid cover, <60% for plastic sheeting < 40% for floating covers.
- Allow cattle slurry store to develop natural crust - < 50%
- Cover solid manure store with plastic sheeting - < 60% reduction increased loss during spreading
- Use slurry band spreading application - 30% for short grass, 60% for trailing shoe in long grass.
- Use slurry injection application techniques - <70% shallow injection.
- Incorporate manure into soil - < 60% reduction if incorporated within 6 hours, < 40% for FM and < 60% for poultry manure if incorporated within 24 hours.
- Slurry acidification - < 50% adjust pH to 6
- Avoid spreading during hot and windy conditions with no rainfall expected
- Humid soils improve diffusion – rainfall upon fertilizer application significantly reduces ammonia emissions by distribution of fertilizer in the soil and mitigation of peak pH peaks

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Official Statistics
Agri-climate report 2022
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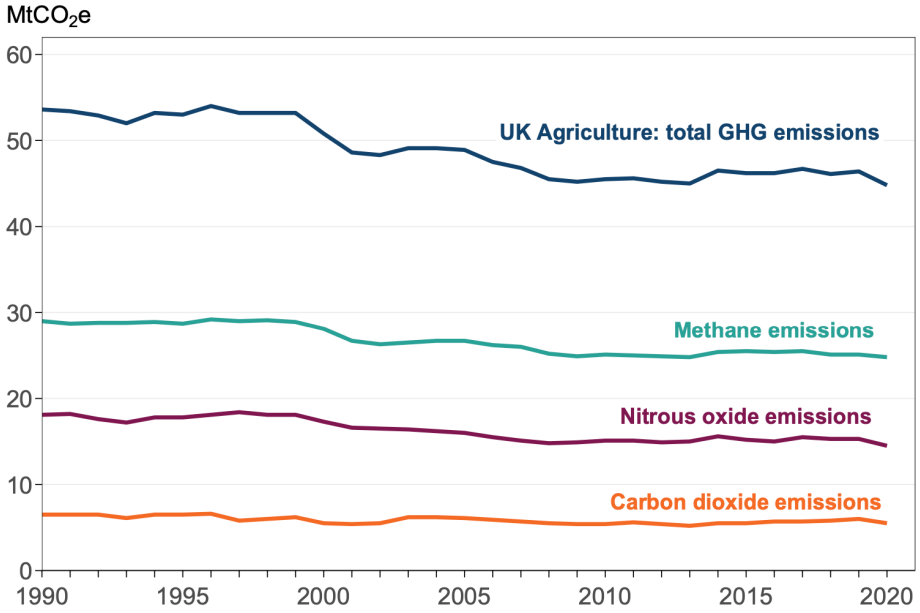
GHG emissions from UK agriculture (MtCO2e)



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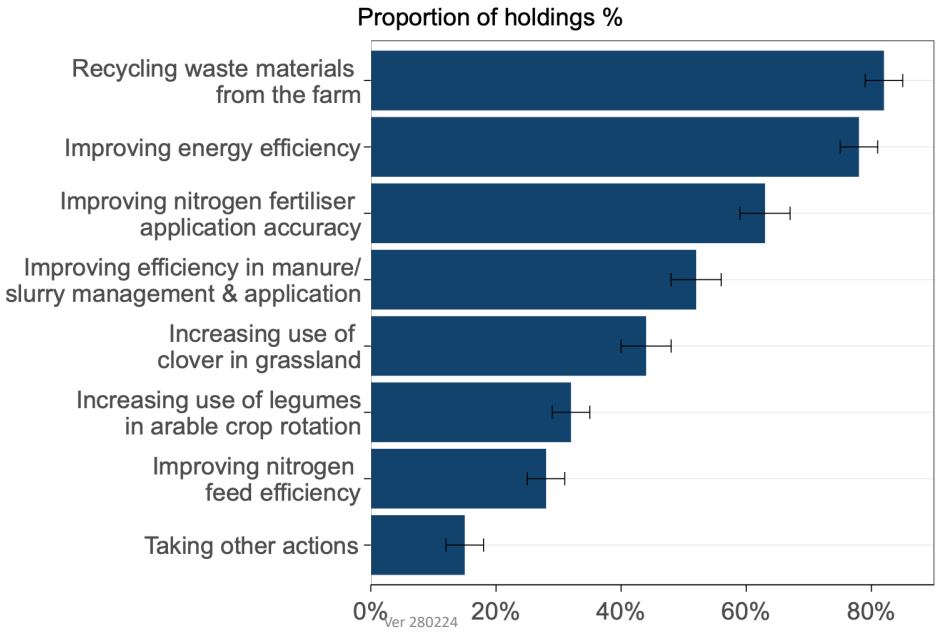
Actions being taken by farmers to reduce GHG emissions



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Emissions of nitrous oxide from UK agriculture by source (MtCO2e)

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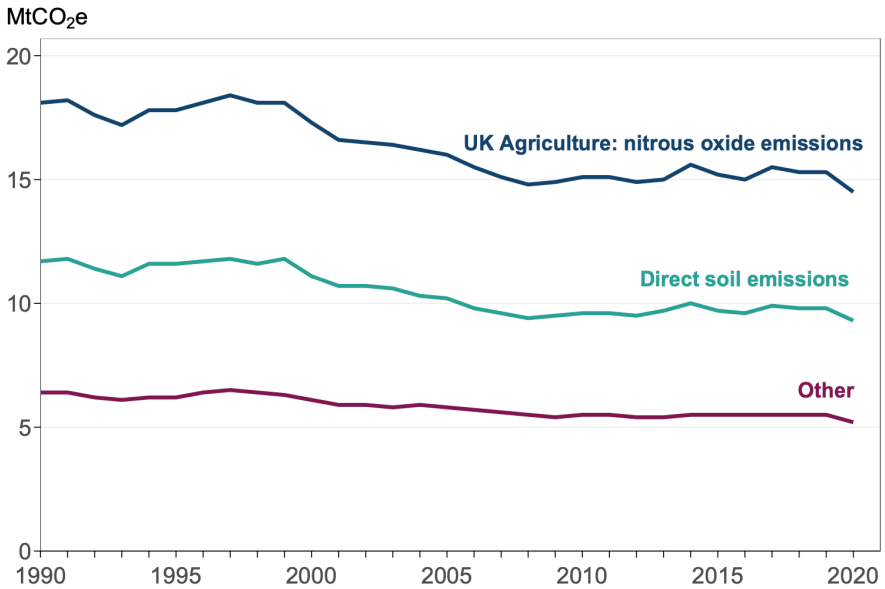

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Nitrous Oxide (N_2O)

- **GHG**
- **300** x CO_2 e
- Produce under **anaerobic conditions** in the soil
- Thiobacillus dinitrogen and other denitrifying bacteria favor these conditions **NO_3^- NO_2^- N_2O**
- Nitrification process **NH_4^+ - NO_2^- NO_3^-** small amounts of **N_2O** produced

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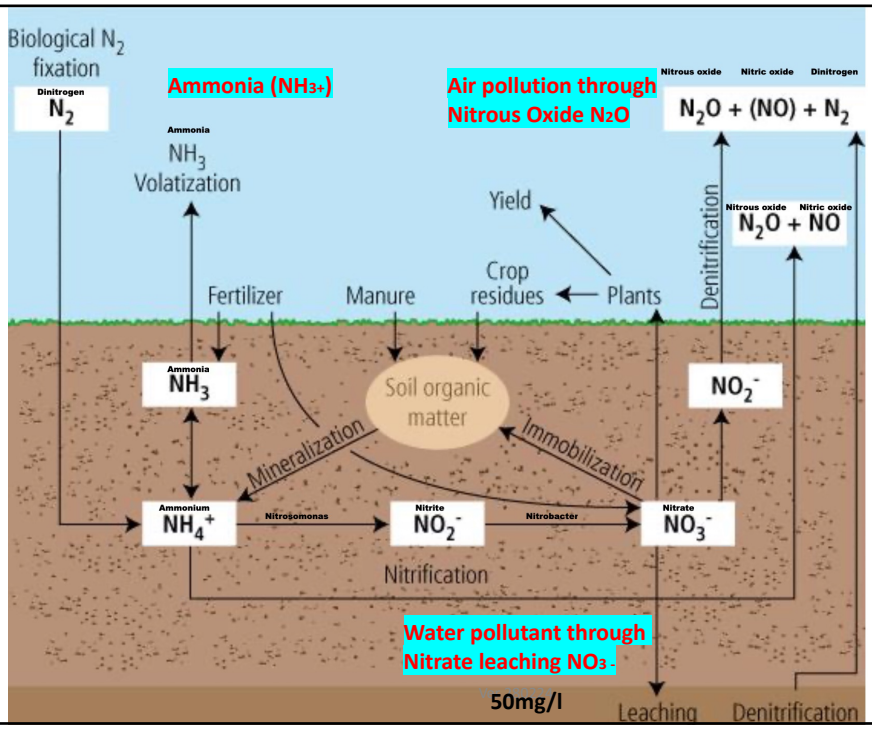

Air pollution during Nitrification process

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Mitigation N_2O

- Drainage - mole - **> 30% clay**
- **Add OM** – improves workability – porosity – reduces bulk density
- **Cover crops** – adding N – exudates – reduce transpiration
- Roots in – **feeding the biota**
- **Avoid Compaction** – reduce cultivations
- **Reduce fertilizer** use – type of fertilizer - timing

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Official Statistics
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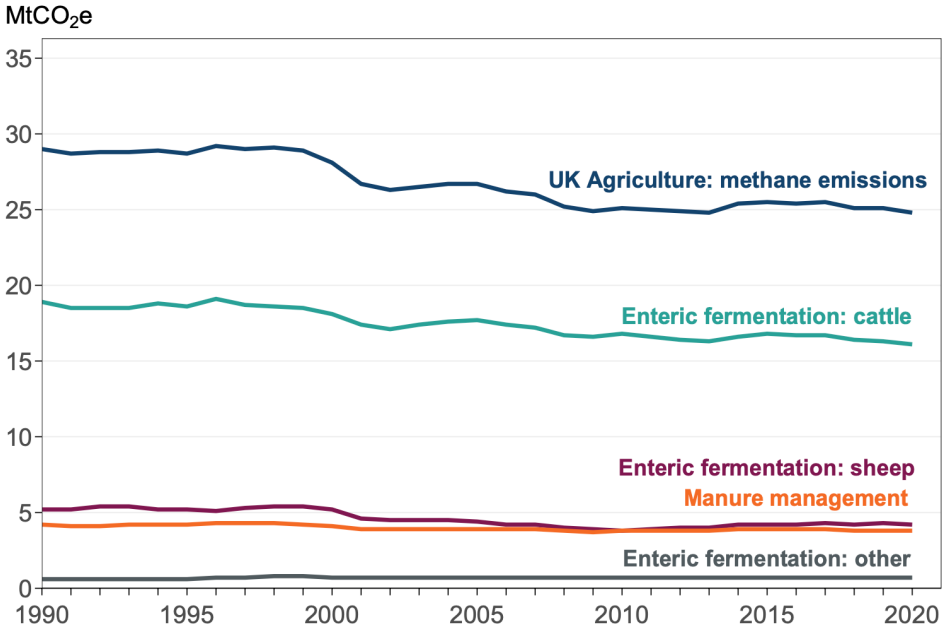
Emissions of methane from UK agriculture by source ($MtCO_2e$)



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Methane (CH_4)

- GHG
- 25 x CO2 e
- Anaerobic conditions
- Ruminants Livestock – feed – efficiency
- Landfill – reduce waste

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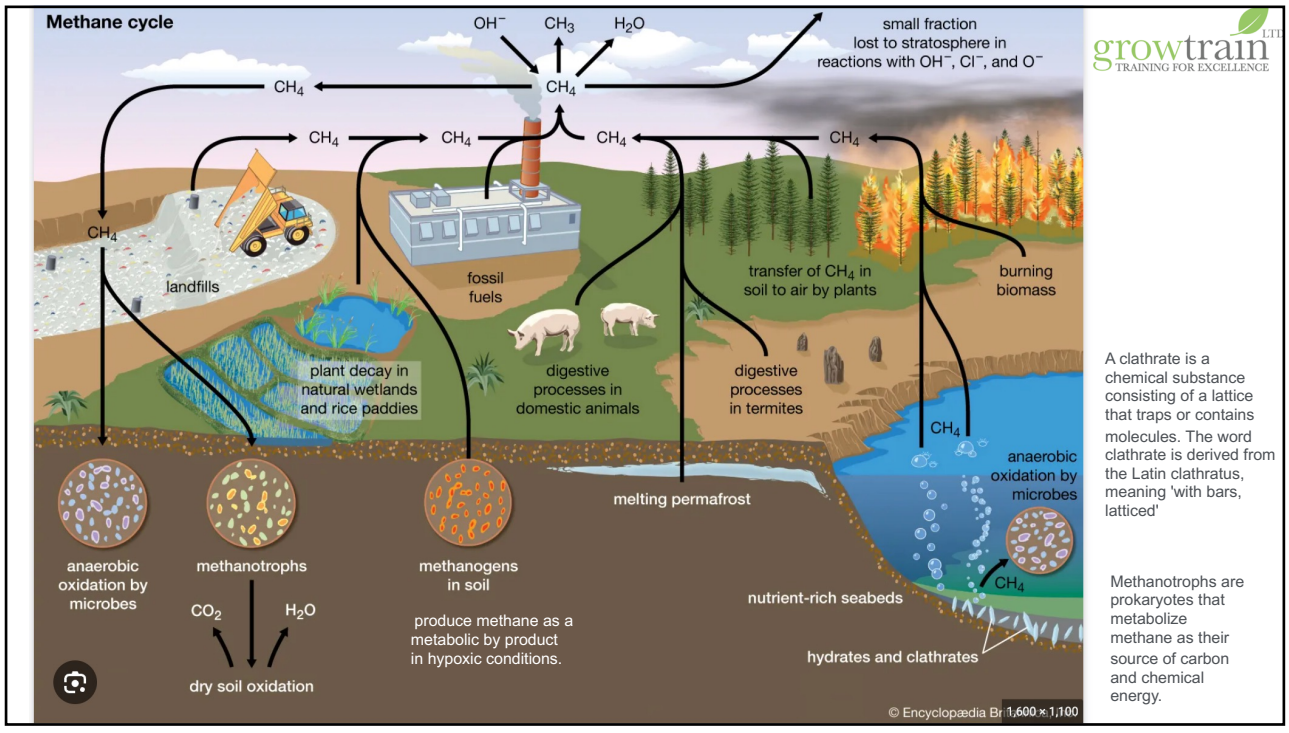

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A clathrate is a chemical substance consisting of a lattice that traps or contains molecules. The word clathrate is derived from the Latin clathratus, meaning 'with bars, latticed'

Methanotrophs are prokaryotes that metabolize methane as their source of carbon and chemical energy.

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Carbon dioxide (CO_2)

- GHG
- Used as equivalents for GHG

Lost by:

- Burning of fossil fuels
- Cultivations
- Breaking down OM
- Biota activity

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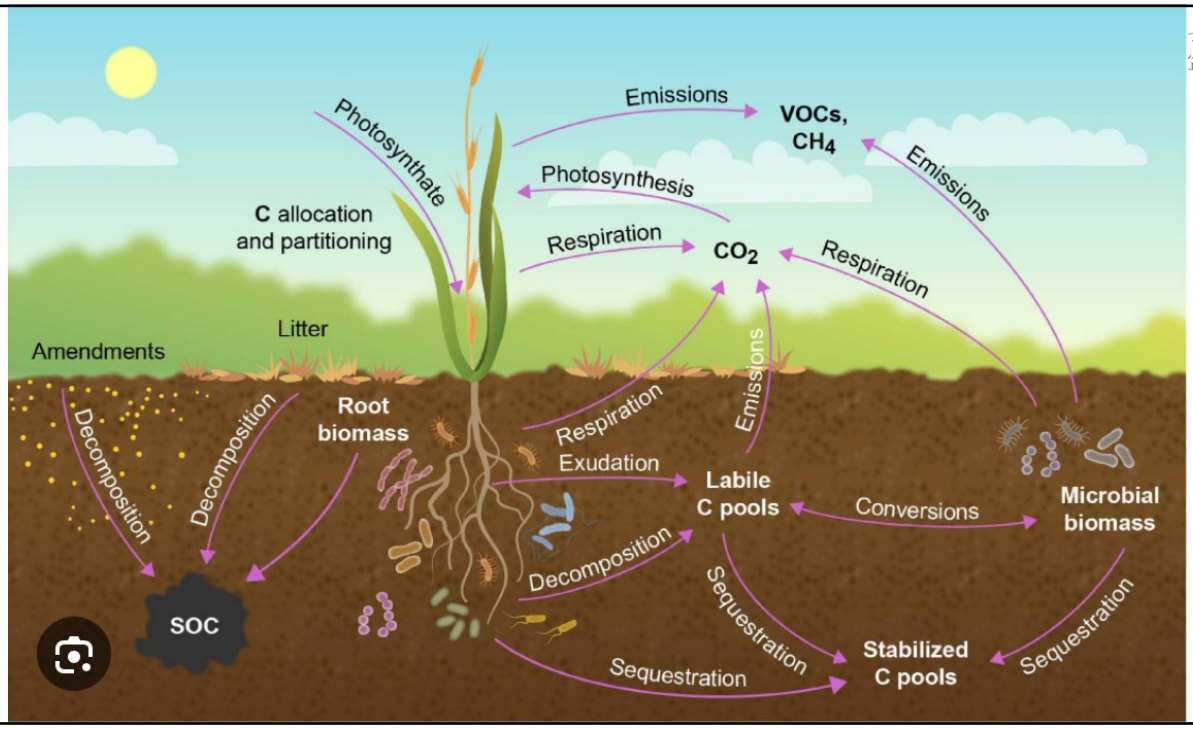

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Mitigate Carbon dioxide (CO_2)

Reduce:

- Cultivations – number and depth
- Cropping - longer
- Rotations

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Odour

Caused through:

Manure & slurry application

Livestock

Mitigation:

Inject

Incorporate

Pre rainfall

Wind direction

Wind strength

Weather conditions

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Odour

For odour to count as a statutory nuisance it must do one of the following:

- **unreasonably** and **substantially** interfere with the use or enjoyment of a home or other premises
- **injure health** or be likely to injure health

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Climate Change

Caused through

- Increase GHG
- Release carbon by cultivations
- Soil conditions – Anerobic – Water logging
- Loss of OM
- Livestock
- Manure & fertilizer application

Mitigations

- Reduce cultivation
- Crop diversity
- Increase rotation
- Add OM
- Livestock reduction
- Livestock diet
- Livestock housing conditions
- Livestock Breeding

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Reducing Carbon Emissions

- Reducing carbon emissions from agricultural production is essential for mitigating climate change. Here are several strategies that can be implemented in agriculture to reduce carbon emissions:
- By adopting these strategies, agriculture can play a significant role in mitigating climate change by reducing its carbon emissions and enhancing the ability of soils to sequester carbon

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Adopt Sustainable Farming Practices

- **No-till Farming**: Reduces soil disturbance, helping to sequester carbon in the soil and decrease CO2 emissions.
- **Cover Cropping**: Using cover crops (e.g., legumes) helps capture carbon and improve soil health by preventing erosion and enhancing soil organic matter.
- **Agroforestry**: Integrating trees and shrubs into farming systems can sequester carbon, improve biodiversity, and reduce wind and water erosion.
- **Crop Rotation and Diversification**: Reduces the need for synthetic fertilizers, improves soil carbon storage, and reduces the emission of nitrous oxide (a potent greenhouse gas).

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Improve Livestock Management

- **Feed Efficiency**: Enhancing the quality of feed for livestock can reduce methane emissions from ruminants (e.g., cows). Feeding livestock high-quality, digestible feed improves the efficiency of digestion, leading to less methane production.
- **Manure Management**: Proper manure handling, such as anaerobic digestion (to capture methane), composting, or storing it in covered lagoons, can reduce methane and nitrous oxide emissions.
- **Rotational Grazing**: Helps improve pasture health and reduces methane emissions from livestock by increasing carbon sequestration in the soil.

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Optimize Fertilizer Use

- **Precision Agriculture**: Using sensors and technology to apply the right amount of fertilizer in the right places at the right times can reduce the over-application of nitrogen fertilizers, which are responsible for nitrous oxide emissions.
- **Slow-release Fertilizers**: Using controlled-release fertilizers or organic alternatives (such as compost) can help reduce the amount of nitrogen lost to the atmosphere as nitrous oxide.
- **Incorporating Manure**: Manure is a natural fertilizer and can be incorporated into the soil promptly to reduce ammonia emissions and increase carbon storage in the soil.

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Enhance Soil Carbon Sequestration

- **Organic Matter Management**: Increasing organic matter in the soil (through compost, cover crops, or reduced tillage) helps improve soil structure and carbon sequestration.
- **Biochar**: Applying biochar (charcoal produced from plant materials) to soils can help sequester carbon and improve soil fertility.
- **Agroecology Practices**: Adopting farming techniques that mimic natural ecosystems can increase biodiversity, reduce the need for synthetic inputs, and enhance soil's ability to sequester carbon

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Energy Efficiency and Renewable Energy

- **Energy-Efficient Equipment**: Upgrading to energy-efficient machinery (e.g., tractors, irrigation systems) can reduce the fuel consumption and associated emissions.
- **Renewable Energy**: Transitioning to renewable energy sources, such as solar or wind, for powering farm operations, greenhouses, or livestock operations can significantly cut emissions from the agricultural sector.

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Carbon Pricing and Incentives

- **Carbon Credits**: Participating in carbon credit programs allows farmers to earn revenue for practices that sequester carbon or reduce emissions. These programs incentivize sustainable practices.
- **Government Incentives**: Subsidies, grants, or tax incentives for adopting green technologies (e.g., solar panels, sustainable fertilizers) can reduce the financial burden on farmers to implement carbon-reducing practices.

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Reducing Food Waste

- **Improved Storage and Transport**: Reducing food waste in the agricultural supply chain can prevent unnecessary carbon emissions associated with food spoilage, transportation, and landfills.
- **Waste Reduction in Consumption**: Encouraging reduced food waste at the consumer level also contributes to lowering agricultural carbon emissions by reducing the demand for overproduction.

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Net Zero

- **NFU 2040**
- **25 year plan 2050**
- Carbon off set by sequestering via photosynthesis
- Reduce cultivations
- Audit farm
- Renewables – solar – biogas – geothermic (Eden Project) – heat source pumps

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Calculating Carbon Emissions on Farm

The **AHDB (Agriculture and Horticulture Development Board) Carbon Calculator:**

is a tool designed to help farmers in the UK calculate the carbon footprint of their farming operations. It is part of a wider initiative by AHDB to support sustainable farming practices and help farmers reduce their greenhouse gas emissions.

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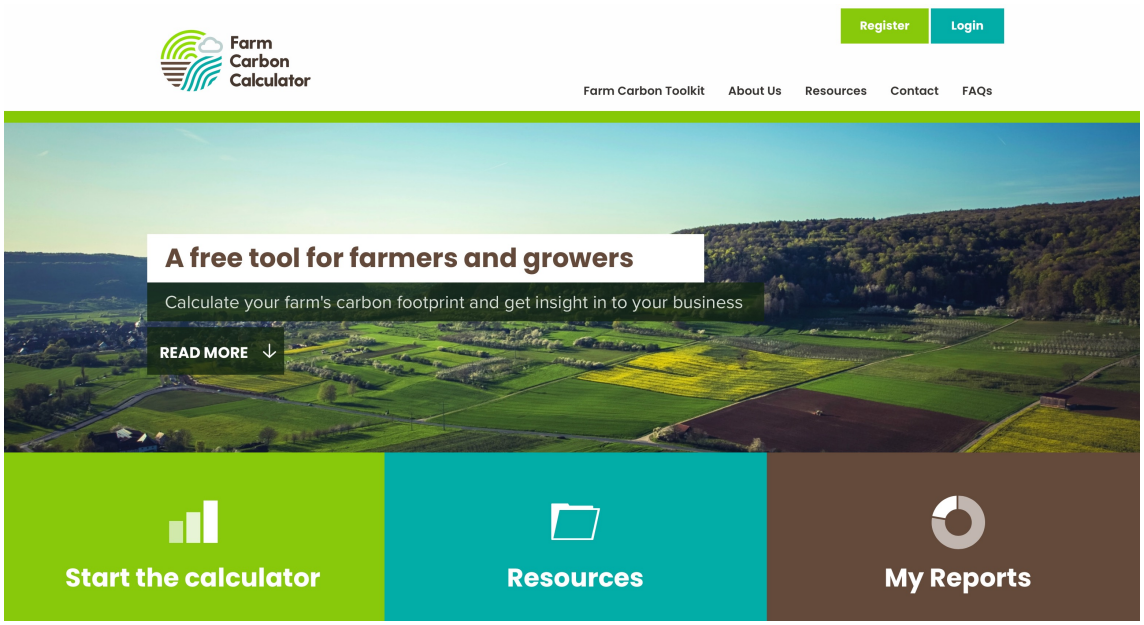
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A free tool for farmers and growers
Calculate your farm's carbon footprint and get insight in to your business
READ MORE
Start the calculator
Resources
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We work with global leading organizations to bring our voice to relevant policy areas on CSA
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Climate Change & the Farm

- Reduce energy use
- Meter – Monitor energy use
- Lights
- Cultivations
- Clear accounting

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Energy Use & Efficiency Improving Electricity

Renewable electricity generation:

- Solar panels, wind turbines or other sources of renewable energy.
- Depending on location, on a hill or low in a valley, limitations for wind turbines close to the M.O.D operations, and any infrastructure that might impinge on landscape character.

Green energy tariffs:

- Works by the supplier promising to match all or some of the electricity you use with renewable energy, which it then feeds back into the National Grid.
- The more people who sign up to a green energy tariff, the bigger the percentage of green energy in the national supply.

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Energy Use & Efficiency Maximising Heating

- Insulation: Check insulation, loft, floor and wall cavity insulation, and gaps in window and door frames.
- Draught excluder for windows and doors.
- Check your thermostat: Turn down your thermostat when your property is not occupied and at night.
- Renewable heat generation: Options for renewable heat generation, ground or air source heat pumps. Viability of some technologies for individual dwellings must be considered, particularly when it comes to electricity supply. Renewable technologies can also be used to heat water.
- Windows: Replacing single-glazed windows with double-glazed windows could reduce heat loss by up to 75%. Restrictions may apply for listed buildings.

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Energy Use & Efficiency Maximising Lighting

- **Fixtures and bulbs:** Upgrading lighting fixtures
- **Natural light:** Use natural light as much as possible
- **Upkeep:** Ensuring that light fixtures are kept clean
- **Security lighting:** Consider solar powered security lighting.
- **Automatic lighting:** Consider automatic lighting for some buildings.

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Energy Use & Efficiency Maximising Office Equipment

Equipment:

- Ensure energy saving features on office equipment are enabled.
- Only purchase equipment with a high energy efficiency rating, and ensure all equipment is switched off when not in use (especially overnight).

Printing:

- Only print when necessary and ensure this is done double-sided.

Heating:

- Prevent use of portable electric heaters where possible, as these are generally energy inefficient.

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Energy Use & Efficiency Maximising Vehicles

Electric vehicles (EVs):.

- Making the switch to electric, could have long term financial benefits and of course environmental benefits, particularly where charging infrastructure is powered by renewables.

Driving economically:

- Drive smoothly, accelerate gently, and read the road ahead to avoid heavy braking.

Maintenance:

- Ensuring your vehicles and machines are well maintained will enable fuel efficiency, for example, ensuring tyres on tractors and machinery are suitably inflated for the task.

Also consider

- (if applicable) livestock watering systems, irrigation systems, greenhouses, grain drying and farm shop operations).

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Energy Efficiency Advice for Arable Farmers

- Largest energy usage on arable farms is **crop storage and drying**.
- **Transport and cultivation** considerable source and the inputs which go into growing crops comprise another large source.
- The '**embodied energy' in fert**. , especially ammonium and nitrate based fert. , with around a tonne of oil used to manufacture each tonne of chemical fertiliser.
- **Reducing artificial fert**. will increase energy resilience & emissions.

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Crop storage and drying

- High temp. dryers require **55litres of oil per ha** of crop dried.
- Controls set to the right setting - **can waste up to 25%** of the energy used.
- Humidity key to crop storage and drying - could save up to **40%** of energy.
- Cooling crops rather than drying them could save **10%**
- Maintenance, ventilation fans at the appropriate size, accurate moisture measurement and aeration.
- Mixed flow driers **save 50%** compared to conventional basic cross-flow driers. Adding recirculation cross-flow driers can save up to **30%** of energy .
- Dryer operating at the right capacity, neither too heavily loaded.
- Harvesting at the **right time** for drying.

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Minimising energy demands

- Can min. cultivation techniques be used?
- Considered growing energy crops.
- Considered changing to lower input crops
- Is each cultivation operation really necessary
- Avoid cultivating in adverse conditions
- Reviewed equipment efficiency
- Are tractor tyres the correct size and operating pressure

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Tractor efficiency

- Use the right implement for the job (not the one that is the most fun to drive!)
- When purchasing new tractors, check fuel efficiency and performance data
- Regular maintenance (smoke is not good ….)
- Check tyre pressures regularly and determine using manufacturers loading and inflation requirements, **and** ground conditions and compaction

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Farm Carbon Toolkit

Field Efficiency

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- Max. work rate and field efficiency can save large amounts of fuel
- Consider the use of precision farming and **autosteer / GPS / RTK**
- Wider implements will reduce % overlap and reduced turning time
- In cultivation terms, the largest single energy saving step possible is switching to a no-till or min-till approach – overall savings of **90%** could be possible.

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Renewable Energy Opportunities

- Solar
- Wind
- Geothermic – Eden Project
- Biogas – from digestate
- Ethanol & Biodiesel from biomass
- Heat pumps
- Heat recovery from wastewater

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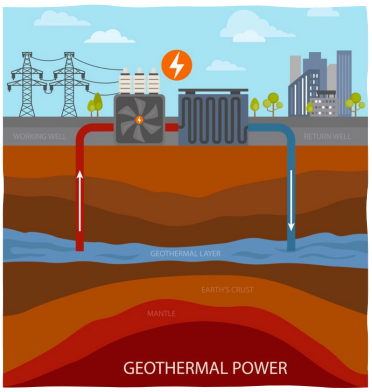
Geothermic at The Eden Project



er Sir Tim Smit with Eden Geothermal Ltd CEO Gus Grand (Eden Project)

othermal power plant at Blue Lagoon, Iceland offers an example of how Britain could ease its energy crisis (Getty/iStock)

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Renewable Energy Funding Opportunities
The below have all currently closed

- Green Home Finance Accelerator
- Industrial Hydrogen Accelerator Programme
- Net Zero Hydrogen Fund Strand 1
- Net Zero Hydrogen Fund Strand 2
- Heat Pump Ready Programme
- Low Carbon Hydrogen Supply 2
- Heat Network Investment Project (HNIP) funding
- Floating Offshore Wind Demonstration Programme
- Alternative Energy Markets (AEM) - Energy Price Signals Study
- Biomass Feedstocks Innovation Programme
- Direct Air Capture and other Greenhouse Gas Removal technologies competition
- Green Distilleries Competition Phase 2

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Biofuels & future Opportunities

- Biofuel is produced over a short time span from biomass.
- Can be produced from plants or from agric, domestic or industrial biowaste.
- Two most common types of biofuels are ethanol and biodiesel, both represent the first generation of biofuel technology
- Biodiesel is a domestically produced, clean-burning, renewable substitute for petroleum diesel.
- Using biodiesel as a vehicle fuel increases energy security, improves air quality and the environment, and provides safety benefits.

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Benefits of using Biodiesel

Using biodiesel as a vehicle fuel increases energy security, improves air quality and the environment, and provides safety benefits.

- Energy Security and Balance. ...
- Air Quality
- Engine Operation
- Safety
- B100 reduces CO2 emissions by 75% and particulate matter by 47% compared with petroleum diesel.

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Waste Management Exemptions

U10 Exemptions - Quantities Limited

- Chalk
- Mushroom Compost
- Milk
- Wood Ash
- Veg Washings

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Waste Management Moving & Disposing

- Licence waste contractor
- Waste disposal notes
- Waste permits
- PAS system
- Protocols

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Waste Management
Manures & Slurry Management

- Storage **10m** from water – **50m** from borehole
- **Application 10m**, from water – **precision (injection) 6m**
- Slurry – Coverage – H&S - Capacity

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Waste Management Hazardous Waste

- **Pathogen** – E.coli – Salmonella – Cyst tape worm eggs
- **Heavy Metals** – Cu, Cd, Cr, Pb, Hg, Ni, Zn also Mo, Arsenic, Floride ?
- **pH** importance – below 5
- Physical contaminant – **plastics - glass**

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Broadcast spreader (splash plate or nozzles)–sideways spread

The slurry is forced under pressure through a nozzle, often onto an inclined plate to increase the sideways spread

Pros:

- Easy to use
- **Range of DMs** can be spread
- **No hoses** to clog

Cons:

- High **NH_{3+}** losses therefore lower **NUE**
- Sward **contamination**
- Potential for **run-off** if it rains after spreading
- Strong **odour**
- Harder to **spread accurately**

Situation:

- Suitable for all land uses

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Trailing Hose

Spreading on grassland for silage in the spring makes good use of the nitrogen, phosphate and potash

Umbilical low trajectory slurry spreading minimises soil compaction

As the hoses are above ground level it can be used in the early stages of a growing crop so might be better suited to a mixed-farm situation

A trailing hose brings the manure down tubes to close to the soil surface, reducing ammonia emissions by 30-35% compared to broadcasting. This equipment can be used on both grassland and arable crops.

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Bandspreader

- Boom of spreader has number of hoses connected to it, distributing slurry close to ground in strips or bands.
- Fed with slurry from single pipe, relying on the pressure at each of hose outlets to provide even distribution.
- Advanced systems use rotary distributors to proportion the slurry evenly to each outlet.
- Band spreaders are very flexible being suitable for both grassland and top dressing growing crops

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Injectors & Trailing Shoe

Slurry injector or trailing shoe prevents contamination of grass for silage or grazing and stock can be returned sooner.

In an NVZ, use of this type of precision spreading equipment allows you to spread to within 6m, (instead of 10m), of a watercourse.

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Trailing shoe spreader

- Similar configuration to band spreader with shoe added to each hose allowing slurry to be deposited under crop canopy onto soil
- Similar advantages to injection but has **lower tractor power** requirement and can be used on taller grass and a wider range of soil types
- Brings manure down tubes from boom to close to the soil surface.
- Metal shoe parts foliage giving manure better access to the soil reducing ammonia emissions by **30-60%** compared to broadcasting.
- Can use for grassland, row crops and arable crops post-emergence.

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Trailing shoe

Pros:

- Easy to use
- Can be **used repeatedly** because no soil slitting
- Low **sward contamination**
- **Reduced NH_{3+} losses** more **available N**
- Low odour
- Bout width known so spreading accuracy easier
- Relatively inexpensive to buy as a basic unit

Cons:

- **Thicker material** can be tricky so may need dilution
- **Pipes can clog** with thicker material
- Only **suitable for grass** as the shoe would damage a growing crop this method is designed to comb through the sward

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Injecting Slurries

- Injecting reduces ammonia nitrogen loss, improves accuracy and minimises odour and contamination.
- Slurry is injected under the soil surface.
- There are various types of injector but each fits into one of two categories:
  - **Open slot shallow injection - up to 50 mm deep**
  - **Deep injection over 150 mm deep**

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Shallow Injection

Situations:

•Difficult on some soils, particular stony conditions, because of wear or damage to cutting discs

•In heavier soils, there is the risk of smearing slits and consequential damage to soil

Pros:

- Known bout width
- Least sward contamination and lowest ammonia losses of all methods
- Min. run-off potential although slits may provide a channel in very poor conditions
- Places the manure 4-6 cm deep in slots cut into the soil 25-30 cm apart and can be used for both grassland and arable crops.
- Deep injection to 10-30 cm can be suitable for some soil conditions.
- Injection can reduce ammonia emissions by 70-90% compared to broadcasting.

Cons:

- More expensive to buy and use - takes a lot of tractor pulling power and consumes more diesel
- Timing of application must be accurate to avoid situations such as slits not closing up when conditions are dry after application

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How much slurry should I apply

Plan what you need:

- Max. of **50 m3/ha** upper limit.
- In practice **30-35m3/ha for any application**, less if on grazing during the season.
- Cutting grass for silage consider what nutrients are needed and plan, taking the soil test result into account.
- You can supply all **P and much of K** needed for a decent first cut, meaning that only NKS fertiliser is required.
- Once **NVZ** closed period for slurry application ends and until the end of Feb, no more than **30m3/ha can be applied** in a single dose, with at least 3 weeks between applications.
- **Early and later** part of the year the nutrients won't be as well utilised so keep application rates as low as possible.

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Three main types of solid manure spreaders commonly used.

Side discharge spreader which features a cylindrical body and pto-driven shaft fitted with flails running along the centre of the cylinder. As the rotor spins, the flails throw the solid manure out to the side

FYM spread prior to reseeding provides all the phosphate and potash needed for the new ley

***In NVZ's** high trajectory spreading, (above 4m), should not be used for slurry application unless at a rate of less than 1mm/hour*

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Dual purpose spreader (side discharge) used to spread FYM

Side discharge spreader - open top V-shaped body capable of handling both slurry and solid manure.

Fast spinning impeller or rotor, throws material from the side of the machine.

Fed with material by an auger or other mechanism fitted in the base of the spreader, sliding gate controls the flow rate of the material onto the rotor

In NVZ's high trajectory spreading, (above 4m), should not be used for slurry application unless at a rate of less than 1mm/hour

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Rear discharge spreader

Spreads solid manures **evenly and accurately**.

Trailer body with moving floor or mechanism delivers solid manure to **rear of the spreader**.

Spreading mechanism can have either **vertical or horizontal** beaters, plus in some cases spinning discs.

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How should digestate & compost be applied to field?

Not spread on frozen, snow-covered or waterlogged ground, or **within 10m** of watercourse.

Liquid digestates can **pollute surface water** if applications are not managed.

Follow best practice

Detailed information can be found in:

- **Code of Good Agricultural Practice** in England
- **Code of Good Agricultural Practice for Wales**21;
- **Prevention of Environmental Pollution from Agricultural Activity** in Scotland.

Image courtesy of ADAS

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How should digestate & compost be applied

- Liquid digestate **using precision equipment** - band spreaders or shallow injectors - incorporated rapidly into the soil. Increases the N available for crop uptake & **reduce the amount lost as NH3+**.
- Broadcasting digestate with a **splash-plate is not recommended**.
- Compost and fibre digestate can be spread with conventional muck spreaders.
- Equipment **maintained & calibrated** for the type of material being applied.
- Rates should be based on the **farm's NMP**

Image courtesy of SRUC

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Waste Management
Environmental Benifits

- Recycle
- Keeps out of water
- Cost
- Reduction artificial fert

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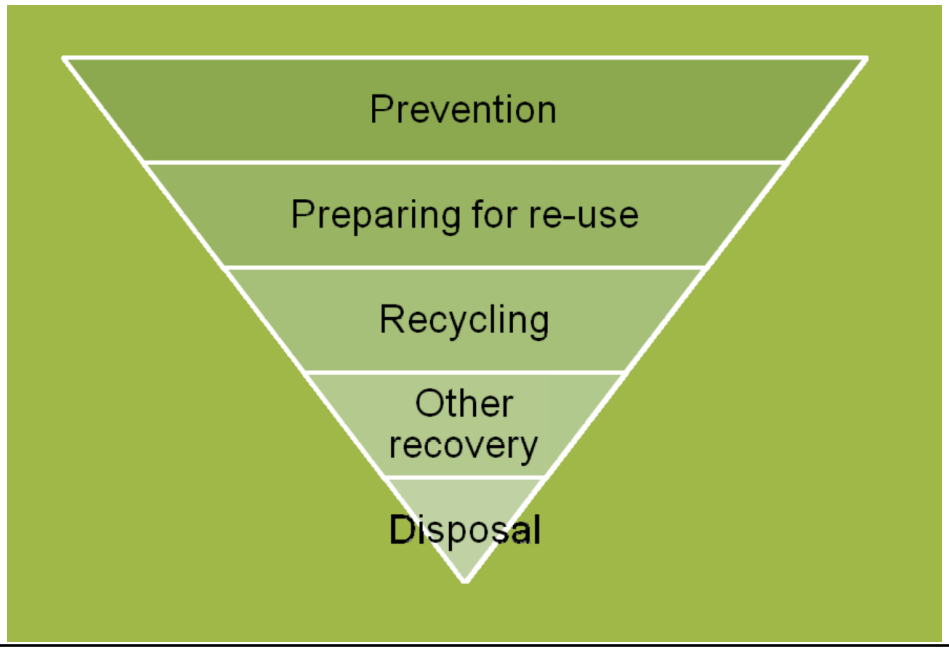
Waste Management



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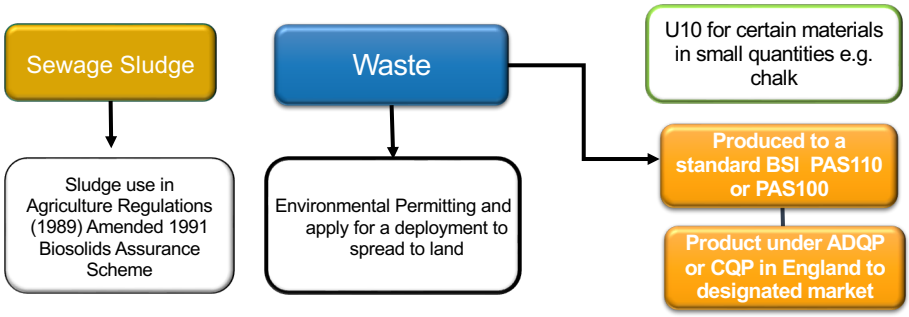
Regulations on use



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