Farm Carbon Calculator

Methodology of the Farm Carbon Calculator

Updates to livestock and emissions factors used in reports ending after 1 April 2025

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June 2025

Methodology v.3.3
Calculation Engine API v2
References v.1.6.4

As a leading carbon assessment tool, The Farm Carbon Calculator is upgraded on a regular basis. This ensures our users benefit from the most recent science, new additional features and a continually improving experience. Read on to find out more.

Methodology V3.3 includes updates to livestock calculations. Users can expect a subsequent update to how we account for land use change emissions before our next scheduled interim update in Autumn 2025.

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Glossary

AD	Anaerobic Digestion
BEIS	Department for Business, Energy and Industrial Strategy
DESNZ	Department for Energy Security and Net Zero
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DMI	Dry Matter Intake
FYM	Farm Yard Manure
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
NH_3	Ammonia
PAS	Publicly Available Standard
SOM	Soil Organic Matter
SOC	Soil Organic Carbon

Document Version

Version	Date	Description
Version 1.0	August 2021	Methodology draft finalised
Version 2.0	May 2023	Methodology draft revised
Version 3.0	April 2024	Methodology draft revised
Version 3.1	October 2024	Methodology draft revised
Version 3.2	April 2025	Latest Methodology finalised
Version 3.3	June 2025	Latest Livestock Methodology finalised

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1. About this methodology document

The purpose of this document is to share details about the methodology that sits behind our Farm Carbon Calculator. With over 8000 farms actively measuring and monitoring their carbon footprint, this methodology matters. In a world grappling with the urgent task of rapidly reducing greenhouse gas emissions, we believe **transparency** in this sector is crucial.

By sharing more about how farm-related greenhouse gas emissions are measured, we hope our calculator users and the wider public will have a greater understanding about the priorities and opportunities to make positive change. We also believe transparency will help us build a greater trust and engagement with our community, and bolster feedback that will further improve our calculator.

2. What's changed?

This methodology documents the updated changes to livestock calculations. You can find older methodology documents and other various guides to help navigate the new livestock section:

- How to update reports to the new livestock emissions methodology
- A guide to enteric emissions and how they're calculated
- Livestock Diet Help Guide | Farm Carbon Calculator
- Manure Storage Systems Guide | Farm Carbon Calculator

3. About the Farm Carbon Calculator

The Farm Carbon Calculator is an industry-leading tool which helps farmers and growers measure, understand and take action on their carbon footprint. We are recognised as one of the UK's most trusted and fastest growing carbon tools. Recommended by the NFU and the Scottish Government, and for use in many projects, we help thousands of active users in the UK and around the world.

"Over 15 years ago, I co-created the Calculator in my spare time alongside being a grower. Created for the benefit of farmers and to help them become part of the climate solution, this ethos remains true today. With world class research behind it, over £500,000 spent on development, and thousands of users, I'm proud to see the impact this tool has had, and continues to have." **– Jonathan Smith, Non-Exec. Director & Impact Manager**

The Calculator is part of the **Farm Carbon Toolkit**, a Community Interest Company dedicated to helping farmers and growers to transition to climate-positive practices. For over a decade, Farm Carbon Toolkit has delivered a range of practical projects, tools and services that have inspired real action on the ground. Organisations we work with include: Duchy of Cornwall, First Milk, Tesco, Yeo Valley and WWF. [Read more]

All users of the Farm Carbon Calculator create an account and accept Terms and Conditions which are detailed on our website: https://farmcarbontoolkit.org.uk/terms.

4. Standards this methodology aligns with

There is no single national or international standard which satisfactorily covers the exact requirements of a farm carbon report. Instead a range of standards are used to ensure quality and compliance.

As such we are actively moving to align with the GHG Protocol agricultural guidance, as well as land-sector based guidance from FLAG. As you will see below, the calculator makes use of the IPCC 2019 and UK GHG Inventory methodologies too.

Our tool can also be used carefully to produce carbon footprints of farm products which exceed PAS 2050:2011 requirements and which are broadly aligned with Life Cycle Analysis guidelines defined by ISO 14044 and PAS 2050 standards. PAS 2050 does not require scope 3 emissions to be included for example, and the Calculator will exceed this requirement in all use cases. In Scotland this means the tool is backed for use by the Scottish Government to fulfill the Carbon Audit requirements outlined in the Whole Farm Plan Scheme and Guidance.

If you have any questions about standards or compliance please get in touch via the details at the end of this document.

5. Independent External Review

We believe it's important for any Carbon Calculator to be independently scrutinised and always ask or check that this is the case. We stand behind this methodology and aim to secure independent external reviews of our work on an annual basis. Our last Carbon Calculator review was completed in February 2025 by the Carbon Trust. This reviewed the user interface, methodology, emissions factors, quality control procedures, and approach to land use change and removals against the GHG protocol, SBTi FLAG and draft LSRG, helping us to identify areas of the tool for improvement. The review highlighted key points of excellence, including:

- The tool encourages knowledge improvement around emissions reductions, with the ability to compare reports over time, there are explanations throughout the calculator and links provided in the full results breakdown to information about emissions sources.
- Users can download their reports in a range of formats (PDF, CSV, JSON).
- The quality of emissions factors - highlighting that BEIS/ DESNZ emissions factors and IPCC 2006 and 2019 emissions factors used where appropriate.

- The calculation methodologies - the IPCC 2006 and 2019 refinement have been used as the main methodological calculation within the calculator, where relevant and employing Tier 2 equations and methodologies, for example for livestock, provides UK specific emissions.
- Users can input primary data to calculate soil carbon sequestration through direct measurements and this method has been validated by a soil science academic.
- The overall layout of sections are consistent and easy to follow throughout the tool.

The review also highlighted areas requiring changes to ensure alignment with FLAG and the draft LSRG and at the time of release are:

- Improving our method to account for historical land use change and amortization of these emissions over a 20 year period
- Adding a land use tracking metric
- Separate reporting of biogenic and non-biogenic emissions
- Inclusion of leased assets
- Data quality scoring for all emissions factors
- Data entry checks to ensure the area entered does not exceed the total farm area
- Data validation checks of report start and end dates

Throughout Spring 2025, our series of updates will address these requirements, as well as bringing improved data entry options and more granularity to the tool.

6. Development cycle

The Calculator's development cycle is summarised in the figure below. The calculator is updated annually in spring though continual updates made usually in autumn - where there is a significant benefit to the end-user.

As we develop the calculator, we believe it's critical to listen to the views, requests and questions of our users to ensure we remain relevant, up to date and as user friendly as possible. We engage in a structured way which involves feedback surveys, and working groups on particular topics which are taken forward during research, development, design, and testing phases.

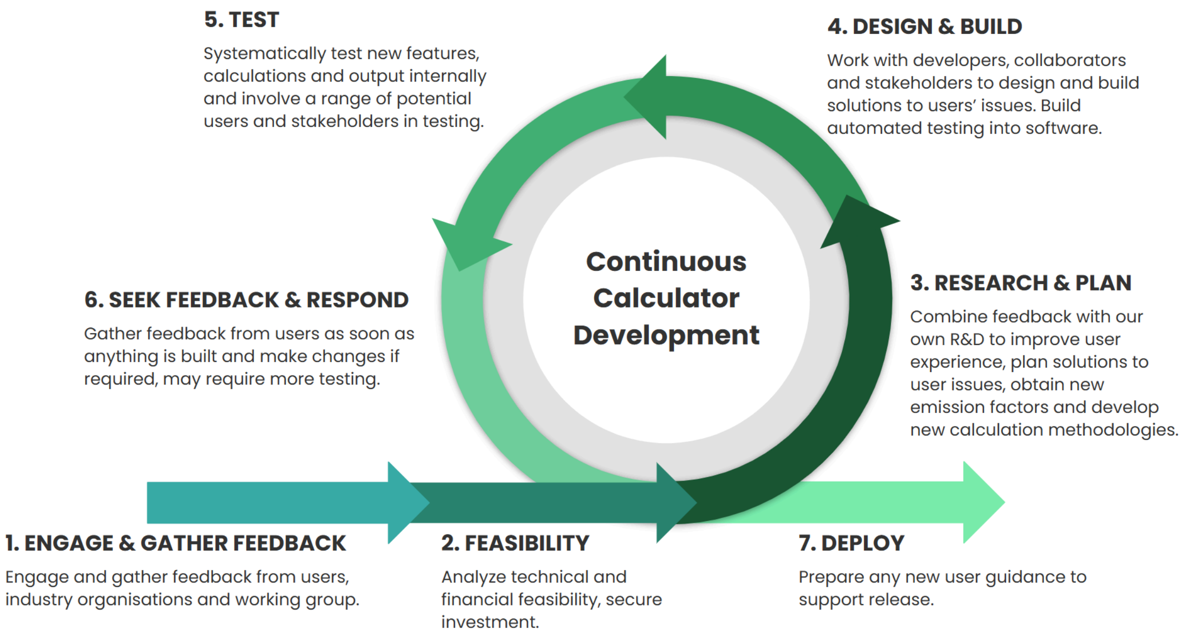

Figure: Farm Carbon Calculator's continual calculator development cycle

7. Structure of the Calculator

The Calculator is split into ten sections, each subdivided into various input fields and produces a report, which can be viewed or exported in a number of ways. Users enter data based on the following guidance:

- What is relevant to their business only
- Looking over the previous 12 months from a single point in time
- Including capital items like machinery and buildings that were purchased during the reporting period within the Inventory section.

8. Scope of the Calculator

The Calculator is foremost a whole farm carbon footprinting tool but can also be used to produce a footprint for each product being produced on a farm - wheat, milk, potatoes for example.

The boundary of the footprint is decided by the user and can be one of three options:

1. **To farm gate only** – i.e. no transport of produce
2. **Farm and distribution** – i.e. including transport to the customer
3. **Farm and distribution through to final customer** – i.e. including processing, and transport to the end customer's doorstep

The Calculator can also be used to footprint other businesses such as processors, distributors or wholesalers, or be used to deliver footprints of farms on the above basis as a service. These are paid services, see our services page for details.

The Calculator covers Scopes 1, 2 and 3 in its calculations:

Scope 1	Also known as **direct emissions**, these are emissions that are owned or controlled by the company such as tractors, farm machinery, gas for heating and from change of land use. Additional emissions arise from N_2O released as a consequence of manure storage and application.
Scope 2	These are associated with emissions resulting from the generation of **purchased electricity** used on the farm.
Scope 3	Also known as **indirect emissions**, associated with the production, processing and distribution of inputs into the farming system. For example, fertilisers and the emissions that occurred in the manufacture of machinery, building materials and other farm infrastructure.
Out of scopes	These are emissions associated with the combustion of biofuels, wood or crop biomass.

Users are encouraged to be as comprehensive as possible with the data they submit for their calculation, as this gives more assurance in terms of the reliability of the results.

All GHG fluxes are reported in the standard tonnes of CO_2e. In the final report, a breakdown of fluxes from carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in tonnes of CO_2e is given, as well as a breakdown of fluxes by scope.

9. Accuracy of results

The accuracy of a carbon footprint report is dependent on a number of factors, including:

- Accuracy of emissions factors;
- Whether a factor is based on actual or proxy values;
- Accuracy of both data collection and data input by the user;
- Level of completeness by the user.

Verification services

At present we do not offer verification of carbon reports for standard users of the Calculator as doing so would require a detailed audit process. We can validate your report - which usually involves a desk-based assessment of it's completeness and accuracy, before checking and communicating the results to you. To enquire about this service and how it can help you - get in touch.

As part of our consultancy service our advisors support farms and companies with enhanced footprint calculations where we also verify the inputs - which provides a level of independent auditing our clients need. We do not currently provide this service to a Third Party verification standard e.g. an ISO standard. To find out more about how we can help you see: Our Services - Farm Carbon Toolkit

Proxy and actual data

Some emissions factors are calculated based on actual data (e.g. litres of red diesel used), and some are based on proxy data (e.g. carbon sequestration of hedgerows). This depends on the availability of reference data for a particular item, and how practical it is for the user to provide data. Some items offer a choice between approaches depending on what information the user has access to – e.g. when tracking the emissions of a car, users have the option to fill actual data or proxy data. A user can either input fuel usage for their car directly if the fuel volume has been logged, or alternatively if the volume has not been recorded users can input the mileage driven by the user. The direct fuel usage provides a more accurate assessment of emissions, whereas the mileage provides a proxy value.

Users will not always have access to the equipment to directly measure GHG fluxes on their farms and so even where a user chooses the "actual" option to input data, the report for a farm or product is still an indirect assessment of its carbon footprint.

Users can, however, input direct measurements of soil organic matter (SOM) or soil organic carbon (SOC) which can be used as direct measures of GHG fluxes from soils. Indirect estimations of sequestration and land use related emissions can also be selected in the Calculator where SOM and SOC sampling is not available. If you are seeking to enter the voluntary carbon market, you should check the requirements of any scheme (more guidance here https://farmcarbontoolkit.org.uk/toolkit-page/getting-paid-for-carbon/).

Confidence levels

In the full results of carbon reports we provide a confidence level column. This ranges from 1 to 3, where results with 3 are those in which we have the most confidence in results. This scale is created by us through an understanding of the accuracy of the emissions/sequestration factors, as well as the likely limitations of user accuracy. For example for emissions from diesel we score this as a 3, because the emissions factors are accurate and we would expect users to also have detailed information on their usage. Conversely, emissions from livestock are scored 1 because whilst users will likely have detailed input data, the inherently variable emissions from biological systems like livestock limits the level of certainty we can have in these results.

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10. References and assumptions

The majority of the emission and sequestration factors that underpin the Farm Carbon Calculator are found within peer-reviewed scientific papers and official government sources, we are transparent about these sources. These references and factors are reviewed and updated annually as part of our update cycle. A full list of current references and assumptions is provided on our website here: [References](https://calculator.farmcarbontoolkit.org.uk/references-0) (https://calculator.farmcarbontoolkit.org.uk/references-0) and at the end of this document.

For ease of use, our calculator is divided into the following data input categories and in subsequent sections of this document, we cover the methodology and emission factors used in each:

- Fuels
- Materials
- Inventory
- Fertility & Cropping (Crops)
- Inputs (agro-chemicals)
- Livestock
- Waste disposal
- Distribution
- Land Use & sequestration
- Processing

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- Waste (legacy) - This section remains available in older reports created prior to April 2024 for backwards compatibility. This was superseded by 'Waste disposal' above.

11. How do we calculate CO_2e emissions?

11.1. Fuels

Emissions from the use of fuels, electricity, travelling and contractors. These include scope 1 (direct), scope 2 (indirect emissions from purchased energy) and scope 3 (indirect – such as processing and transport) emissions, including 'well-to-tank' emissions factors.

Fuels and electricity

All of the items in liquid fuels, electricity, gas fuels, heat & steam, solid fuels, accommodation, public transport and contractors are derived from DEZNZ UK GHG inventory conversion factors (107). The exceptions are:

Table 1. Fuels References

Section	Item	Reference	Notes

Liquid fuels	AdBlue	69	
Electricity & Gas Fuels	Electricity/Gas exported to the grid	61	GHG protocol agricultural guidance on how electricity export is recorded
Electricity	Tariff with known carbon footprint	N/A	To enable users to input a known carbon footprint of an electricity supplier. Simply direct input of a CO_2e figure.
Gas Fuels	Biogas for Off grid	38	Accounting for gas burnt on site but generated from AD plants.
Deliveries	Known carbon footprint	N/A	To enable users to input a known carbon footprint of deliveries. Simply direct input of a CO_2e figure.
Operations	My Operations	37	Emissions factors are based on average fuel usage for the operation and the UK GHG inventory conversion factors.
	Contractors Operations (C.O)		

Travel

All data is from the UK GHG inventory conversion factors (107) and includes all scope 3 emissions, including 'well-to-tank' emissions factors. The 'miles per gallon' function for cars is calculated as a function of miles travelled divided by miles per gallon, to calculate gallons of fuel used. The emissions factor for petrol or diesel in litres is then multiplied by the conversion factor for litres to gallons.

Operations

Users can enter various farm activities under this header based on whether they have carried out the operations themselves or have a contractor undertaking them. This enables the operations to be taken into account if fuel usage is unknown. **If fuel usage is known, this can be entered under Liquid fuels> Diesel> Red Diesel and users should not double count it here**. Field operation data draws from the AHDB's HGCA Calculator (37), multiplied by the diesel emissions factor (scopes 1 & 3) from the UK GHG inventory conversion factors (107). For contracted emissions these will all fall under scope 3 emissions, whereas your own field operations entered this way will be split between scope 1 and scope 3. Additional calculations made for the following options under field operations:

Table 2. Bale Assumptions

Section	Item	Notes
Hay baling	Small rectangular	Assumes 250 bales/ha
	Large round	Assumes 15 bales/ha
	Heston	Assumes 7.5 bales/ha

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11.2. Materials

The embodied energy in a range of materials that may be used on farms, including aggregates, metals, wood and plastics. These are all Scope 3 emissions.

Emissions factors are drawn from the Inventory of Carbon and Energy (ICE) database, either version 2.0 (2), version 3.0 (2a) or version 4.0 (108). Priority is given where possible to the latest version 4.0, then 3.0, and lastly 2.0. A range of metrics are used, including tonnes, kg, m^2 and m^3. The exceptions from this source are listed below, with some being derived from factors in the ICE database, and not drawn directly from ICE:

Table 3. Materials References

Section	Item	Reference	Notes
Aggregates	Recycled asphalt	60	Allows the asphalt factor to be adjusted for recycled content
Various	Plastics	107	The plastic emissions factors are taken from the UK GHG inventory conversion factors database.
Fencing	Complete fencing options & components	108 & Calc	Calculating the posts and wire used in common fencing options, multiplied by emissions factors from the Inventory of Carbon and Energy.
Vineyard trellising	Vineyard trellises	107 & 108	Calculations for trellises based on the materials used
Consumables Packaging	Various	107 & Calc	The emissions factors are calculated based on average weight of the item and material used
Consumables agriculture	Bale wrap	107 & Cal	Factors by the bale provided based on average weight of material used
Horticultural materials	Netting	107 & Calc	Factors for netting based upon material usage
Horticultural constructions	Poly tunnels	108 & Calc	Factor calculations based on material usage for standard polytunnel constructions
Surfacing	Surfaces, subbase, decking, etc.	107 & Calc	Factor for materials from ICE, and area emissions factor based on calculation for surface requirements.
Computers	Laptops & Desktops	109	Proxy emissions factors for embodied energy in computers from IDEMAT
Water	Mains water & sewage	107	Scope 3 emissions for water supply and disposal
Water	Non-mains	N/A	Figure simply recorded as water use. No emissions specifically – any fuel or electricity used in pumping or treatment will be picked up under Fuels.

Cleaning products, detergents, etc.	Various	103	Product specific emissions. "Product not listed" options in each section are the average of specific product emissions included in that section.

11.3. Inventory

This section covers the embodied energy in larger items like machinery and buildings (capital items). The GHG protocol guidance advises that all capital items are accounted for 'up-front' in the year of emissions. This can mean spikes in carbon footprints associated with inventory, and therefore by entering capital items through this tab you have the ability to easily separate out these emissions from the rest of your footprint. We also offer the option to account for capital items over a period of 10 years, although this is not GHG protocol compliant. This is a similar principle to financial accounting, as the capital item emissions are depreciated over 10 years, so 10% of emissions are apportioned each year.

Most of the emissions factors for inventory items are again derived from the Inventory of Carbon and Energy, version 2.0 (2), 3.0 (2a) or 4.0 (108). It is also possible to create "custom" projects and group together any items from the "Materials" section to be treated as capital items. The other data sources are:

Table 4. Inventory References

Section	Item	Reference	Notes
Vehicles	Cars	91	Values from the Average of all GM vehicles produced and used in the 10 year life-cycle.
Farm machinery	Tractor, harvesters, etc	3	Based on horsepower of machine – a proxy for emissions
Agricultural buildings		108 & calc	This calculation is based on a standard agricultural portal building constructed of concrete floor, steel frame, roof sheets and timber slat walls. Based on a per m2 calculation.

11.4. Fertility & Cropping (Crops)

This section covers the carbon dioxide and nitrous oxide emissions from organic fertility sources (including manure application to soils) and plant residue biomass inputs to cropping systems.

Crop emissions

Emissions from crops are worked out from the amount of crop (fresh yield) that results in crop residues. Crop residues contribute nitrogenous material to the soil, some of which goes through denitrification to N_2O. To give a more accurate representation of how much crop residue has been left in the field, multiple levels of crop residue management practices are available for input into the calculator. For perennial crops such as soft fruits, top fruits, biomass crops and green manures, temporary grasses and cut forages, the renewal rate of the plant (*i.e.* the frequency at which plants are removed and replaced with new seeds, seedlings or rootstocks) is included in the calculation so it does not overestimate the amount of crop residues.

The methodology used is that of the IPCC 2019 (94), using emissions factors specific to the UK from the UK GHG Inventory and its annexes (111a & 111b) with reference to the GHG protocol agricultural guidance (61).

Some crops (for example Christmas Tree crops) have been included for data capture only and do not currently have an emissions factor associated with them.

Organic fertility emissions

The application of organic fertility sources to soils will result in N_2O emissions as the nitrogen content of the product undergoes de/nitrification by soil bacteria, which is then volatilised into NH_3 and NO_x, and is leached or runs off from where it is applied. Manure produced from livestock onsite or bought in can be entered in this section, as it calculates the emissions associated with the application to soils. To calculate these emissions we use the IPCC methodology for N_2O emissions from managed soils (94), with nitrogen content data pulled from the RB209 (96b), direct N_2O emissions factors drawn from analyses of UK agricultural soils (51), and indirect emissions factors from the UK GHG inventory (111) and the IPCC (94). These sources allow us to calculate the emissions coming from organic fertility applied to grassland or arable soils during different periods of the year, with separation of different products (*e.g.* from separated slurry components to chemically treated paper crumbs). Conventional application will often have the highest emissions associated with it, and therefore we have included options for alternative application approaches and for post-spreading incorporation based upon in-field research (114).

Table 5. Crops References

Section	Item	Reference	Notes
Crops	Agricultural	111b & 94	IPCC methodology, and factors from UK GHG Inventory
	Horticultural	111b & 94	IPCC methodology, and factors from UK GHG Inventory
Market Garden		111b & 94	IPCC methodology, and factors from UK GHG Inventory, item entry in kg or per unit scale
Biomass Crops	Willow coppice	111b & 94	IPCC methodology, and factors from UK GHG Inventory
	Poplar coppice		
	Miscanthus		

	Hemp		
	Switchgrass		
Green manures, temporary grasses and cut forages	All leguminous and non-leguminous green manures and managed perennial grasses	111b & 94	N_2O emissions as part of the N fixation process. IPCC methodology, and UK specific N fixation rates. Note that this does not take account of any carbon sequestration – this is covered under soils in the sequestration tab. Users can enter different crop management regimes. Unmanaged grassland should not be entered here.
Organic fertility sources		51, 94, 96, 111, & 114	Emissions are calculated as per the IPCC methodology or N_2O from managed soils, using UK data sources for N content application approach.
Anaerobic digestion	Running an AD plant	7 & 38	Average emissions of various processes in running an AD plant, including CO_2 and CH_4 emissions. Based on tonnes of biowaste input.
Lime & Mineral fertilisers	Lime, rock phosphate, rock potash, K fertiliser, Gypsum	3 & 111c	Emissions from processing of lime and mineral fertilisers
	Phosphoric acid	109	Emissions associated with production of the amendment
	Potassium sulphate	90	
	Sulfuric acid	109	
Plant raising media		16	Average of emissions for all common plant raising media used in horticulture using the LCA approach

11.5. Inputs

The GHG emissions associated with energy input in the production of agro chemicals and, in the case of fertilisers, the N_2O emissions resulting from their application to UK soils.

Fertilisers

This is split into two sections: one is for generic fertilisers, such as Ammonium Nitrate (Product with 33.5% N) or Urea. These are derived in two parts; the manufacturing emissions from Brentrup *et al.* 2018 (48), and the application emissions from IPCC chapter 11, N_2O emissions from managed soils (94). These fertilisers require the user to specify the country of origin which should be provided on the invoice or labelling (and has a big effect on the carbon footprint of the product).

The second section is for specific solid or liquid fertilisers, including those manufactured by Yara, CF, Origin and Mole Valley Farmers. These are derived from either communication of the recipe and production methods directly from the manufacturer and then calculation using the generic fertiliser values (CF and Mole Avon) or based on verified and certified carbon footprints of those products (47, 48, 49).

The user input figures are based on tonnes or litres of product used.

Two further functions enable users to enter:

1. A specific blend of fertiliser, based on known % of N:P:K, multiplied by tonnes of product used
2. A specific known footprint of a fertiliser, using kg of CO_2e per kg of product, multiplied by tonnes of product used

Overall GHG emissions for fertilisers are based on four processes, and measured in tonnes CO_2e:

- Production emissions to factory/plant gate
- Direct N_2O emissions to soil
- Indirect NH_3 and NO_x losses (to leaching and volatilization)
- Emissions from urea hydrolysis (applies to Urea products only)

All calculations are based on IPCC methodology. The emissions factors for in field emissions are based on MIN-NO project findings (47), which are UK specific, and considered an improvement on IPCC methodology because they are more accurate.

Application is assumed to be by broadcast or application of solution. Nitrogen inhibitors are not accounted for.

Sprays

Sprays can be entered as either "generic" or "actual" depending on whether the product in question is listed in our database. Both rely on the same underlying emissions factors for fungicides, growth regulators, herbicides, insecticides, molluscicides or adjuvants (18, 40) multiplied by the concentration of active ingredient used. For "actual" sprays, we have a database of over 6000+ specific branded sprays and their active ingredient content taken from the UK pesticides register.

11.6. Livestock

This section covers nitrous oxide and methane emissions from animals' enteric fermentation, manure storage methods and the embedded emissions from imported feeds and bedding.

Livestock Data Entry

The livestock calculation has been updated in 2025 to include increasing levels of accuracy. There are several variables which require user input (marked as required) and some which are optional, to increase the specificity of the calculation:

- Category of livestock, by age and use ***(Required)***

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- Average number of livestock per reporting period ***(Required)***
- Reporting period in weeks **(*Required*, default = 52)**
- Average live weight per head
- KPI details include; livestock sold during the reporting period, the killing out percentage, dairy yield in litres per head per year, milk fat and protein percentage
- Manure storage management options reported as a percentage of the reporting period in use **(*Required* - options must to add up to 100%)**
- Livestock feed intake options reported as percentage of the reporting period animals ate the diet option and dry matter intake in kg per head per day OR
- An average dry matter intake option in kg per head per day, applied to the whole reporting period

If no data is entered into optional fields, defaults will be used based on UK GHG inventory values published in the supplementary information and annexes (111) and the IPCC 2019 methodology (94).

Tiers of Calculations

The list below outlines the relevant tiers of calculation that are broadly outlined by the IPCC. The livestock calculation can be tailored to increase accuracy from the default for most livestock on the calculator at Tier 2 (UK specific) to Tier 3 (Farm- level system specific). See Table 6 for default liveweights of livestock and the tiers available for each livestock category.

- Tier 1 - IPCC International values used for other livestock categories (Alpacas and Llamas).
- Tier 2 - UK GHG inventory default enteric emissions factor and default liveweights. User data for manure storage practices.
- Tier 2a - An enhanced tier 2 methodology for cattle and sheep takes user entered average dry matter intake (DMI) data and employs the UK GHG inventory linear equation. Either default or user data for liveweights. User data for manure storage practices.
- Tier 3 - User entered data for feed type and DMI for the reporting period for cattle and sheep. Either default or user entered liveweights and manure storage practices.

The following sections will outline the calculations involved in producing **enteric CH_4 emissions**, **manure storage emissions** and **manure production data**. Please note, to account for emissions associated with **manure application** to soils, enter options under 'Organic fertility sources' within the Crops tab. The exception to this is 'In field manure' as storage and application are intrinsically linked and should be entered under the manure storage types in the Livestock section.

Table 6. A full list of livestock categories used in the Calculator, their default liveweights and calculation tiers available.

Category		Category description	Live weight (kg)	Tiers available
Dairy cattle	Dairy cows	Lactating, "dry" or in-calf dairy cows	685	3, 2a, 2

Category		Category description	Live weight (kg)	Tiers available
	Dairy heifers	First pregnancy or first lactation dairy cattle under 3 years of age	466	3, 2a, 2
	Dairy replacements (1+ years)	1-3 year old female cattle to join the dairy herd who are not in-calf or lactating	466	3, 2a, 2
	Calves (under 1 year)	Cattle under 1 year old	185	3, 2a, 2
	Dairy beef (1+ years)	Dairy breeds not lactating but fattened for beef (over 1 year old)	550	3, 2a, 2
	Bulls for breeding	Dairy or beef breeding bulls	900	3, 2a, 2
	Calves (under 1 year)	Cattle under 1 year old (male or female)	200	3, 2a, 2
	Beef cattle	12-18 months cattle for finishing (male or female)	385	3, 2a, 2
Beef cattle	Beef finishing heifers	18-30 months heifers for slaughter	600	3, 2a, 2
	Beef suckler cows	Lactating, “dry” or in-calf beef suckler cows	550	3, 2a, 2
Beef cattle (continued)	Bulls for breeding	Dairy or beef breeding bulls	900	3, 2a, 2
	Finishing bulls (beef)	Bull for beef 12+ months (e.g. cereal-fed)	900	3, 2a, 2
	Beef replacement heifers	First pregnancy or first lactation beef suckler cows under 3 years of age	400	3, 2a, 2
	Beef finishing steers	12-24 months steers for slaughter	600	3, 2a, 2
	Adult sows	Sows (including sows in pig, sows being suckled and dry sows being kept for further breeding)	185	2
	Breeding gilts (female)	Gilts (including gilts in pig and gilts not yet in pig)	110	2
	Adult boars	Boars for service	200	2
	Piglets	Fattening swine under 20 kg	5	2
Pigs	Weaner pigs (under 20kg)	Fattening swine under 20 kg	15	2
	Weaner pigs (over 20kg)	Fattening swine 20-80 kg	30	2
	Finishing pig (porker)	Fattening swine 20-80 kg	77	2
	Finishing pig (cutter)	Fattening swine 80+ kg	88	2
	Bacon pigs	Fattening swine 80+ kg	94	2

Category		Category description	Live weight (kg)	Tiers available
	Barren sows for finishing	Barren sows for fattening >80kg	185	2
Sheep	Ewes	Adult ewes	70	3, 2a, 2
	Replacement ewes	Shearling or replacement ewes (1+ years)	60	3, 2a, 2
	Rams or tups	Adult rams or tups	110	3, 2a, 2
	Lambs	Young sheep under 1 year	25	3, 2a, 2
Poultry		Chickens – layers	2.25	3
		Chickens – broilers	2.25	3
		Chickens - pullets	2	3
		Breeding stock (all poultry)	0.045	3
		Ducks	3.25	3
		Turkeys	13.2	3
		Geese	7.5	3
		Pheasants	1.2	3
Other livestock		Goats	50	2
		Horses	450	2
		Deer (all)	60	2
		Llamas	60	1
		Alpacas	110	1

Enteric fermentation calculations

Methane can be generated from the digestion of ruminant animals (known as enteric fermentation). Age, sex, pregnancy and lactation can all affect an ruminant's metabolism and therefore their enteric CH_4 emissions and excretion rate. Therefore livestock are separated by these categories (as shown in Table 6) to improve GHG emissions estimates, which are inherently variable.

There are three available levels to the calculation for enteric CH_4 emissions which increase in accuracy depending on the level of data users enter. If no information about DMI or diet is provided, the calculation will use Eq. 1a for a tier 2 estimate.

Eq 1a. Enteric Methane Emissions - Default Calculation (all animals):

Enteric CH_4 emissions = (default enteric EF * head) * 28 / 1000

- Enteric CH_4 emissions: total emissions per head per year as CO_2 equivalents (tCO_2e)
- default enteric EF: UK GHG inventories value (kgCH4/head/year)
- 28: CH4 to CO2e conversion factor
- 1000: kilograms to tonnes conversion

If an average DMI is entered (which may be carried over from legacy reports made before changes to the livestock section), this tailors the calculation to use Eq. 1b which employs the UK GHG inventory method of utilising a linear equation to estimate enteric CH_4 for cattle and sheep. This option corresponds to the enhanced tier 2a estimate.

Eq 1b. UK GHG Inventory DMI-based (cattle & sheep):

Enteric CH_4 emissions = (DMI.m.constant * DMI + DMI.c.constant) * 365 * head * 28 / 1,000,000

- Enteric CH_4 emissions: total emissions per head per year as CO_2 equivalents (tCO_2e)
- DMI.m.constant, DMI.c.constant: UK GHG inventory equation components (with DMI produces gCH4/head/day)
- DMI: Daily dry matter intake (kgDM/day)
- 365: daily to annual conversion
- head: Number of livestock
- 28: CH4 to CO2e conversion factor
- 1,000,000: grams to tonnes conversion

If specific diet information is known for cattle and sheep, such as the DMI of different feed types ingested, a tailored calculation can be employed, which can combine multiple feed types and their effect on CH_4 emissions. Eq. 1c calculates enteric CH_4 emissions based on the digestible and gross energy content of different feeds and the dry matter intake for the livestock over the reporting year. This option provides a tailored tier 3 estimate.

Eq 1c. Diet and Intake-based (cattle & sheep):

Enteric CH_4 emissions = (GEi * (Ym / 100) * 365) / 55.65 * head * 28 / 1000

GEi = GE * DMI

Ym = 9.75 - 0.05 * (DE / GE * 100)

- Enteric CH_4 emissions: total emissions per head per year as CO_2 equivalents (tCO_2e)
- GEi: Gross energy intake (MJ/head/day)
- Ym: Enteric methane conversion factor (%)
- GE: Gross energy content (MJ/kgDM)
- DE: Digestible energy content (MJ/kgDM)

- 365: daily to annual conversion
- 55.65: Energy content of methane (MJ/kgCH4), used to convert from MJ to kg.
- head: Number of livestock
- 28: CH4 to CO2e conversion factor
- 1000: kilograms to tonnes conversion

Manure production and storage calculations

How manure is stored and handled can affect the amount of CH_4 and N_2O emissions. This requires estimating how much manure and nitrogen in manure is produced by livestock, which is now reported in the results.

Eq 2. Manure Production:

kgManure = animal liveweight * VS excretion rate * 365 * head

- kgManure: Total manure produced (kg) [Also known as VS]
- liveweight: Average animal liveweight (tonnes)
- VS excretion rate: Daily manure production per tonne of animal (kgVS/tAnimal/day) [IPCC defaults]
- 365: daily to annual conversion
- head: Number of livestock

Eq 3. Manure Nitrogen Content:

kgManure nitrogen = animal liveweight * VS_n excretion rate * 365 * head

- kgManure nitrogen: Quantity of nitrogen in manure (kgN) [also known as VS_n]
- VS_n excretion rate: Daily nitrogen in manure per tonne of animal (kgVS_n/tAnimal/day) [IPCC defaults]
- 365: daily to annual conversion
- head: Number of livestock

Methane from the storage of manure is calculated by taking the CH_4 producing capacity of different manure types (converting into kg) and multiplying by the CH_4 conversion factor for that storage system as per Eq 4.

Eq 4. Methane from Manure Storage:

CH_4 from manure = kgManure * (Bo * 0.67) * (MCF / 100) * 28 / 1000

- Bo: Methane producing capacity (m3CH4/kgManure)
- 0.67: m3 to kg conversion factor
- MCF: Methane conversion factor of storage system (%)

Nitrous oxide is also emitted depending on available nitrogen in the manure and the storage system. The calculation includes both direct (Eq. 5) and indirect N_2O emissions, with indirect N_2O split between volatilisation (Eq. 6) and leaching and run off emissions (Eq. 7). The larger proportion of emissions will often result from direct (microbial processes breaking down nitrogen compounds) and volatilisation (lost as ammonia or nitrogen oxides to the atmosphere) processes, because indirect emissions from leaching and run off are often mitigated by the storage systems, although this varies.

Eq 5. Direct N_2O Emissions from Manure:

$$\textbf{Direct } N_2O \textbf{ from manure} = \textbf{kgManure nitrogen} * \textbf{direct } N_2O \textbf{ EF} / 100 * (28/44) * 265 / 1000$$

- direct N_2O EF: Emissions factor for direct N_2O conversion (%)
- 28/44: N_2O-N to N_2O conversion
- 265: N_2O to CO_2e conversion factor

Eq 6. Indirect N_2O Emissions from Volatilisation:

$$\textbf{Indirect volatilisation } N_2O = \textbf{kgManure nitrogen} * \textbf{FracVol} * \textbf{EF4} /100 * (28/44) * 265 / 1000$$

- FracVol: Fraction of nitrogen with volatilization potential (fraction)
- EF4: Emissions factor for N_2O conversion via volatilization (%)

Eq 7. Indirect N_2O Emissions from Leaching and Runoff:

$$\textbf{Indirect leaching nitrous oxide} = \textbf{Remaining kgManure nitrogen} * \textbf{FracLeach} * \textbf{EF5} /100 * (28/44) * 265 / 1000$$

$$\textbf{Remaining kgManure nitrogen} = \textbf{kgManure nitrogen} - (\textbf{direct } N_2O\textbf{-N} + \textbf{indirect volatilisation } N_2O\textbf{-N})$$

- Remaining kgManure nitrogen: Nitrogen remaining after direct N_2O-N and volatilisation N_2O-N losses (kgN)
- FracLeach: Fraction of nitrogen with leaching potential (fraction)
- EF5: Emissions factor for N_2O conversion via leaching (%)

Total Emissions Data

The sum of the outputs of equations 1 to 7 equal the total emissions from livestock. The total emissions are then scaled to the reporting period entered by the user:

Eq 8. Total Emissions from Livestock:

$$\textbf{Total emissions from livestock} = (\textbf{Enteric } CH_4 \textbf{ emissions} + CH_4 \textbf{ from manure} + N_2O \textbf{ direct from manure} + \textbf{Indirect volatilisation } N_2O + \textbf{Indirect leaching } N_2O) * \textbf{reporting period scale}$$

- reporting period scale: (Reporting period in weeks) / 52

Unfortunately, the IPCC guidelines do not currently incorporate a comprehensive GWP* methodology and there is no consensus on how this methodology would be used. Our teams are working in this area and monitoring guidance as it develops but this does not yet form part of our current methodology.

Please see notes in our Livestock Wizard for how to estimate average head of animals in each category over a 12 month reporting period, our Livestock Diets Wizard to help calculate the percentage components of feed constituents for guidance on completing this section of the Calculator.

Animal feeds

These indirect emissions are very important to assess the holistic carbon impacts of livestock production. If feed has been grown on-farm, users can enter it under 'Feed by-products of on-farm cropping'. Users should still enter the relevant crop / yield information under the crops section with the appropriate residue management option.

The Calculator primarily uses data from the 'GFLI database' (105). Some further data for non-organic feed is obtained from 'GHG emissions from food' (17), along with all the data for organic feeds.

Some emissions factors for feed blends and supplements have been calculated, based on the known constituents of certain blends. This research has been undertaken by Farm Carbon Calculator, based on discussions with feed companies. Using the constituent parts, and data from the GFLI database, the footprint of certain blends has been calculated.

Table 7. Animal Feeds References

Section	Item	Reference	Notes
Generic Feed blends	16% CP Dairy blend	105 & Calc	Barley/Wheat/Maize [30%], Sugar Beet Pulp [15], Soybean Meal [12], Rapeseed Meal [15], Distillers' Grains [10], Soya Hulls [10], Molasses [6], Minerals & Vitamins [2]
	18% CP Dairy blend	105 & Calc	Barley/Wheat/Maize [28%], Sugar Beet Pulp [14], Soybean Meal [18], Rapeseed Meal [12], Distillers' Grains [10], Soya Hulls [10], Molasses [6], Minerals & Vitamins [2]
	21% CP Dairy blend	105 & Calc	Barley/Wheat/Maize [25%], Sugar Beet Pulp [13], Soybean Meal [25], Rapeseed Meal [14], Distillers' Grains [5], Soya Hulls [10], Molasses [6], Minerals & Vitamins [2]

	24% CP Dairy compound	105 & Calc	Maize/Wheat/Barley [27%], Sugar Beet Pulp [15], Soybean Meal [30], Rapeseed Meal [15], Distillers' Grains [10], Soya Hulls [10], Protected Proteins [10], Molasses [5], Minerals & Vitamins [3]
	18% Fibre blend	105 & Calc	Sugar Beet Pulp [30%], Soya Hulls [30], Wheat Bran [15], Rapeseed Meal [12], Distillers' Grains [5], Molasses [6], Minerals & Vitamins [2]
	18% starch compound	105 & Calc	Maize/Wheat/Barley [45%], Sugar Beet Pulp [15], Soybean Meal [14], Rapeseed Meal [13], Distillers' Grains [5], Molasses [6], Minerals & Vitamins [2]
Calf rearing	Whole milk powder	68	Analysis of production within the research paper.
	Milk replacement powders (all)	105, 67 & 68	Formulations of milk replacement powders taken from 67 and relevant emissions factors applied to constituent parts based on information in 105 and 68
	Calf rearing pellets	105 & 67	Formulations of milk replacement powders taken from 67 and relevant emissions factors applied to constituent parts based on information in 105.
Supplements	Novapro	72	Estimate of emissions associated with constituents of Novapro (factor to be reviewed upon acceptance of product into GFLI database)

Animal bedding

Animal bedding materials emissions factors are taken from the Inventory of Carbon and Energy (ICE) database v4.0 (108) and from the GHG emissions of various straw (17) with users entering tonnes of product for an annual reporting period. If bedding has derived from on-farm production, users can enter it under 'Bedding by-products of on-farm cropping'. Users should still enter the relevant crop/ yield information under the crops section with the appropriate residue management option.

11.7. Waste

This section covers emissions from landfill, and the savings from recycling and composting materials. Users enter data on their annual outputs of waste and recycling from a range of specific categories of materials.

Emissions factors for all waste disposal emissions, including landfill, recycling, combustion and composting come from the UK GHG inventory conversion factors (107).

11.8. Distribution

For businesses that have distribution beyond the farm gate within the scope of their report, this section calculates the emissions from distributing and refrigerating food products.

Users can enter actual data on fuel used per year on distribution. If they don't have this data they can use proxy data based on three variables – delivery distance per journey, weight carried per journey, and number of journeys per year.

All the emissions factors are derived from the UK GHG inventory conversion factors (107). Average values are used, and for road haulage this is based on 50% laden lorries (on a round trip).

Users are encouraged to carefully map and describe the scope of the study, and at what point the responsibility for food transport is passed on to the next actor in the supply chain. This will be different for every business, and may range from farm gate all the way through to the customer's house.

Refrigeration emissions are calculated from refrigerant losses from food storage on the farm (or in packhouses/warehouses/food processing). This is calculated by using the GHG protocol worksheet (12), an online tool to calculate the accurate emissions from refrigerant gases, per year. The figure from the spreadsheet can then be entered directly into the Calculator by the user.

Users are reminded not to double count any data entered in the Fuels section in Distribution (and vice versa).

11.9. Sequestration

This section calculates carbon sequestered by perennial plants and soils on the farm.

Data sources: All of the sequestration factors are proxy figures, except for actual Soil Organic Matter (SOM) or Soil Organic Carbon (SOC) measurements. A range of sources are used in this section.

Table 8. Sequestration references

Section	Item	Reference	Notes
Soils	Soil Organic Matter	79	Based on actual SOM and/ or SOC from soil samples, users enter data on field size, depth of measurement, bulk density and SOM/SOC results over a given time period. This is converted into changes in volume of soil organic carbon and therefore the amount of carbon sequestered (or emitted) as per IPCC methodology.
	Soil Organic Carbon		
	Carbon stocks		A log of baseline soil carbon stocks in fields. These results do not impact on the overall carbon balance, they are therefore just for reference.

Woodland	Detailed analysis	104	Users input the species, age range and area of woodland. Assumptions of average yield class, average spacing, and no thinning is applied. This is the recommended approach.
	Mixed, coniferous and broadleaf	104	Average values per hectare of types of woodland, over a 200 year average.
	In field trees	104	A per m2 value based on average sequestration rates for deciduous woodland.
Hedgerows	Managed (generic)	22, 25, 99, & 101	Based on the length and width of managed hedges – i.e. those cut on a regular basis. Sequestration factors based on averages from peer reviewed studies.
	Managed hedgerow under 15 years old	87, 88, 89	Based on the length and width of managed hedges - gives age-specific sequestration factors based on UK soil data from peer-reviewed studies.
	Managed hedgerow planted more than 15 years ago	87, 88, 89	Based on the length and width of managed hedges - gives age-specific sequestration factors based on UK soil data from peer-reviewed studies.
	Large growth with trees	25, 99, & 100	Based on the length and width of large growth hedges with trees – i.e. those trimmed or laid on an irregular basis, forming large structures with in line trees. Sequestration factors based on averages from peer reviewed studies.
Perennial crops	Top fruit, stone fruit and nuts	26	Average sequestration values per hectare. Includes biomass only – soil and grass sequestration excluded.
	Grape vines	28	Covers sequestration in biomass only, not soils.
	Miscanthus	29	Sequestration rates in biomass and soils
	Willow & poplar	30	Covering sequestration in both soils and biomass
Field margins	Uncultivated	25	Area of field margins that are permanently uncultivated. Sequestration rates include soil carbon.
Wetlands	Permanent	13	Area of permanent peaty wetland that is ungrazed
Land use change	(various)	23	Changes which result in losses of carbon, such as woodland to arable. This is from carbon losses in soils and biomass. These are considered to be uncommon in a UK setting, but must be accounted for if they occur. These are one off losses. Users should not enter values in here if they have also calculated SOM measurements for exactly these areas of land use change - though this is thought to be an unlikely occurrence.

	Marshy grassland to degraded wetland	44	Sequestration in biomass and soils on a continuous basis. Users should not enter data here if they have included SOM measurements of the same area.
Habitats/ Higher tier stewardship	(various)	44	Sequestration in biomass and soils on a continuous basis for various habitats, as defined in the Countryside Stewardship Scheme for higher level scheme (HLS) options. The underlying data is based on mid-tier options, and only HLS schemes with an equivalent mid-tier option in the study are included. Users should not enter data here if they have included SOM measurements of the same area.
Cultivated peat soils	Peat soils	21	N_2O emissions from cultivated peat soils. Also CO_2 losses from soils – unless users are able to supply SOM results, in which case only the N_2O changes are accounted for. Average values are used from the source.
Uncultivated peatland soils	(various)	82	Emissions from varying states of uncultivated peatland in line with the Peatland Carbon Code.
Countryside Stewardship	(various)	63	Sequestration in biomass and soils on a continuous basis for various habitats, as defined in the Countryside Stewardship Scheme. Users should not enter data here if they have included SOM measurements of the same area.

11.10. Processing

This section calculates carbon emitted as a result of the processing of food and drink including common manufacturing inputs.

Data sources: In this section all of the emission factors are proxy figures, but are all allied to real input quantities, not estimates of items used in a process.

Table 9. Processing references

Section	Item	Reference	Notes
Sugar	Cane & Beet	105	GFLI figures for cane sugar production
Fermentation	CO_2 release	113	Direct CO_2 released from the fermentation process
Processing products	*Various*	80	Proxy figures for processing input
	CO_2 canisters	N/A	Enter the volume of CO_2 used
	Granulated Sugar	62	Based on cradle to gate for british sugar

Cleaning Products detergents, etc	*Various*	103	Product specific emissions factors
Packaging	Wine bottles	108	Emissions factor per bottle for 750cl glass wine bottle
	Recycled glass bottle	71	Emissions factor for Encirc recycled "green glass wine bottle" 750cl
	Jars and Bottles	108	Proxy figures for packaging input
	Corks	95	Proxy figures for packaging input
	Crates and Packaging	108	Proxy figures for packaging input
	Various	108	Proxy figures for packaging input
Refrigeration	Refrigerant usage	12	Refrigerant use and losses
Water	Mains water	107	Use of mains water
	Mains waste water	107	All waste water released to a mains treatment system
	Non-mains	N/A	Figure simply recorded as water use. No emissions specifically – any fuel or electricity used in pumping or treatment will be picked up under Fuels.

12. Other Calculations we use

Fat and protein corrected milk (FPCM)

To calculate the milk KPI (kg CO_2e per kg FPCM) we use the following equation from the FAO 2010 that corrects to the energy equivalent in milk of 4% fat and 3.3% protein (referenced in 81). If the user does not enter a fat or protein content of their milk, the Calculator assumes 4% fat and 3.2% protein. The calculator also assumes 1 litre = 1.035 kg.

$kg\ FPCM_{[4\%F,\ 3.2\%CP]} = (0.337 + 0.116 * fat\ \% + 0.06 * protein\ \%)$

Conversions from individual GHG emissions to CO_2e

The emissions factors for some items in the calculator come from sources such as individual GHG emissions. For example, when accounting for crop residue emissions it is necessary to calculate the direct and indirect N_2O emissions. The calculations provide a value for the quantity of N_2O released, which we then convert into CO_2e per N_2O in accordance with the IPCC guidelines. The three main GHGs are calculated using the following ratios under GWP100 (53):

CO_2 to CO_2e per CO_2 = 1 : 1

CH_4 to CO_2e per CH_4 = 28 : 1

N_2O to CO_2e per N_2O = 265 : 1

13. What farm business information do users enter?

At the start of all reports users are asked to input information about their farm business. Our team is working to ensure we remain best in class for the privacy and data security of your farm business information. Details of how we process your data is outlined in our Terms and Conditions of Software Access and Use, but to summarise this, we do not use or sell this information for purposes other than helping us calculate your carbon footprint and presenting this back to you.

The following farm business information is asked for in reports:

1. **Business category** (s) - Arable, Beef, Dairy, Fruit, Lowland grazing, Mixed (arable/livestock), Other, Pigs, Potatoes, Poultry - layers, Poultry - meat, Sheep, Upland grazing, Upland grazing with common land, Vegetables, Vineyards, Processing, Wineries, Non-agricultural business, Market garden

2. **Farm area** - each of the following categories of land use, in hectares:
   - Cultivated land - all arable and horticulture land that involves soil cultivations (or non/min-till systems)
   - Grassland - temporary and/or permanent grassland, generally used for livestock grazing, and/or forage
   - Non-cropping land - any land not falling under cultivated land or grassland. For example woodland, scrub or other uses which are not generally used for agricultural or horticultural use.

3. **Postcode** - which helps us locate the area where you farm for the purposes of UK benchmarking of results

4. **Certification** - Businesses can mark any certification or assurance schemes they belong to.

5. **Farm Business identification number** - Businesses can enter an identification number relevant to them, e.g. in England this may be your SFI number. In future upgrades we envisage this number to be used to better connect your report to your farm, and therefore help when integrating outside services like mapping, and other software you may use on your farm.

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15. Contacting us

We welcome Calculator users to contact the Calculator team with questions, suggestions and comments at any time.

For general enquiries, please email: calculator@farmcarbontoolkit.org.uk or reach out to a member of our team.

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