Methodology of the Farm Carbon Calculator

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Glossary

AD	Anaerobic Digestion
BEIS	Department for Business, Energy and Industrial Strategy
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
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 finalised
Version 3.0	April 2024	Methodology draft finalised
Version 3.1	**October 2024**	**Methodology draft finalised**

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1. Introduction

The purpose of this document is to share details about the methodology that sits behind our Farm Carbon Calculator, a valuable tool used by thousands of farmers, growers and organisations to inform better decision making.

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 build a greater trust and engagement with our community, with feedback that will further improve our calculator.

2. About the Farm Carbon Calculator

Started in 2008, the Farm Carbon Calculator is one of the longest running and most popular carbon calculators available in the UK. It is one of the three main carbon calculators for UK farmers and growers which are recommended by the NFU to its members. It enjoys widespread support from its users, both in terms of its comprehensive nature and ease of use.

The Calculator is owned and managed by the **Farm Carbon Toolkit** (FCT), an enterprise that helps farmers and growers to measure, understand and take action to reduce their carbon emissions and increase carbon sequestration. FCT is run by farmers for farmers.

Over the years, the Calculator has attracted interest from other countries as well, showing its potential to positively influence carbon management on farms beyond the UK. From the outset, it has measured carbon sequestration and we remain a strong advocate of the potential for farmers and growers to sequester carbon in soils and biomass.

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

3. How the Calculator is structured

The Calculator is split into ten sections, each subdivided into various input fields. Users enter data according to the following guidance:

- What is relevant to their business only
- Take a recent point in time and cover everything over the previous 12 months
- Capital items go in the Inventory section (e.g. machinery and buildings) and include everything under 10 years old

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4. Calculator Scope

The Calculator has always been designed to be used as a whole farm carbon footprinting tool. However, it can also now be used to produce a footprint on a per product basis (e.g. wheat, milk, potatoes).

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. house doorstep

The Calculator can also be used to footprint other businesses such as processors, distributors or wholesalers - see our services page.

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.

5. 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.

At present, we do not offer verification of carbon reports for standard users of the Calculator, as this requires a detailed audit process. As part of our consultancy service, we do support farms and companies with enhanced footprint calculations and verifying the inputs, which provides a level of independent auditing. However we do not currently provide this service to a Third Party verification standard e.g. an ISO standard.

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 have detailed information on their usage. Conversely, emissions from livestock are scored 1; whilst users will likely have detailed input data, emissions from biological systems are inherently variable which limits the level of certainty in these results.

6. References and assumptions

The majority of the emission and sequestration factors that underpin the Farm Carbon Calculator come from peer-reviewed scientific papers and we are transparent about these sources. A full list of current references and assumptions is provided on our website here:
https://calculator.farmcarbontoolkit.org.uk/resources or
https://calculator.farmcarbontoolkit.org.uk/references-0

Each time we perform a major update to the calculator (typically annually), we review all references and factors; this comprises over 1000 data entry lines.

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/capital
- Fertility & Cropping
- Inputs (agro-chemicals)
- Livestock
- Waste

- Distribution
- Land Use & Sequestration
- Processing

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/).

7. How do we calculate CO2e emissions?

7.1. 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 BEIS GHG conversion factors (86). The exceptions are:

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 s 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 the average fuel usage and the BEIS GHG conversion factors.
	Contractors Operations (C.O)		

Travel

All data is from BEIS GHG conversion factors (86) 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 per gallon, fuel used and miles travelled.

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**. Contractors data draws from the HGCA Calculator (37), multiplied by the diesel emissions factor (scopes 1 & 3) from BEIS GHG conversion factors (86) for all contractor operations with the additional calculations made for the following:

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

7.2. 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 database, either version 2.0 (2) or version 3.0 (2a). A range of metrics are used, including tonnes, kg, m^2 and m^3. The exceptions from this source are:

Section	Item	Reference	Notes
Aggregates	Recycled asphalt	60	Allows the asphalt factor to be adjusted for recycled content
Various	Plastics	86	The plastic emissions factors are taken from the BEIS GHG conversion factors database.
Fencing	Complete fencing options & components	2 & 2a	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	2 & 86	Calculations for trellises based on the materials used
Consumables Packaging	Various	86	The emissions factors are calculated based on average weight of the item and material used
Consumables agriculture	Bale wrap	86	Factors by the bale provided based on average weight of material used
Horticultural materials	Netting	86	Factors for netting based upon material usage
Horticultural constructions	Poly tunnels	2a	Factor calculations based on material usage for standard polytunnel constructions
Computers	Laptops & Desktops	91	Proxy emissions factors for embodied energy in computers
Water	Mains water & sewage	86	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.

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7.3. Inventory

This section covers the embodied energy in larger items like machinery and buildings (capital items). In a similar principle to financial accounting, these are depreciated over 10 years, so 10% of emissions are apportioned each year.

Most of the emissions factors are again derived from the Inventory of Carbon and Energy, either version 2.0 (2) or version 3.0 (2a), but given only 10% weighting per year. 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:

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		2 & 2a	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.

7.4. Fertility & Cropping (Crops)

This section covers the carbon dioxide and nitrous oxide emissions from fertility and biomass inputs to cropping systems (fertilisers, organic manures, mineral fertilisers).

Emissions from crops are specifically 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 (i.e. the frequency at which plants are removed and replaced with new seeds, seedlings or rootstocks) of the plant 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 (92b & 92c) with reference to the GHG protocol agricultural guidance (61).

Some crops (for example Christmas Tree crops) have been included for data capture only.

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Section	Item	Reference	Notes
Crops	Agricultural	92b & 94	IPCC methodology, and factors from UK GHG Inventory
	Horticultural	92b & 94	IPCC methodology, and factors from UK GHG Inventory
Biomass Crops	Willow coppice	92b & 94	IPCC methodology, and factors from UK GHG Inventory
	Poplar coppice		
	Miscanthus		
	Hemp		
	Switchgrass		
Organic fertility sources	Compost	51	Fresh weight of bought-in compost. Includes both N_2O and CH_4 emissions.
	Manure (composted)	94 & 96	An average of annual measured emissions, including both N_2O and CH_4
	Manure – exported	8	A carbon offset/transfer when manure is sold to another farm (which then becomes a carbon emission to them). Same value as composted manure.
Anaerobic digestion	Digestate	51	Bought in digestate – average emissions calculated from AD plants
	Running an AD plant	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 & 92c	Emissions from processing of lime and mineral fertilisers
	Phosphoric acid	95	Emissions associated with production of the amendment
	Potassium sulphate	90	
	Sulfuric acid	95	
Green manures, temporary grasses and cut forages	All leguminous and non-leguminous green manures and managed perennial grasses	92b & 94	N2O 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.

Plant raising media	(all)	16	Average of emissions for all common plant raising media used in horticulture

7.5. 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 34.5% N) or Urea; these are derived from Brentrup *et al.* 2018 (48). 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 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 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 300 specific branded sprays and their active ingredient content taken from the UK pesticides register.

7.6. Livestock

This section covers nitrous oxide and methane emissions from animals' enteric fermentation and manures, and emissions from imported feeds and bedding.

Livestock

Livestock emissions are complex and are based on IPCC calculation methodologies. There are several variables which require user input:

- Category of livestock, by species, age, use and live weight
- Numbers of livestock, on average, per year – both for the current year and the previous year
- Manure handling – the percentage (on an annual basis) of manures handled as slurry, FYM, daily spread, or in-field.
- Adjustments for dairy cattle (based on annual milk yield) and beef cattle (based on average liveweight).

A full list of livestock categories used in the Calculator is available below:

Category		Category description
Dairy cattle	Dairy cows	Lactating, "dry" or in-calf dairy cows
	Dairy heifers	First pregnancy or first lactation dairy cattle under 3 years of age
	Dairy replacements (1+ years)	1-3 year old female cattle to join the dairy herd who are not in-calf or lactating
	Calves (under 1 year)	Cattle under 1 year old
	Dairy beef (1+ years)	Dairy breeds not lactating but fattened for beef (over 1 year old)
	Bulls for breeding	Dairy or beef breeding bulls
Beef cattle	Calves (under 1 year)	Cattle under 1 year old (male or female)
	Beef cattle	12-18 months cattle for finishing (male or female)
	Beef finishing heifers	18-30 months heifers for slaughter

Category		Category description
Beef cattle (continued)	Beef suckler cows	Lactating, “dry” or in-calf beef suckler cows
	Bulls for breeding	Dairy or beef breeding bulls
	Finishing bulls (beef)	Bull for beef 12+ months (e.g. cereal-fed)
	Beef replacement heifers	First pregnancy or first lactation beef suckler cows under 3 years of age
	Beef finishing steers	12-24 months steers for slaughter
Pigs	Adult sows	Sows (including sows in pig, sows being suckled and dry sows being kept for further breeding)
	Breeding gilts (female)	Gilts (including gilts in pig and gilts not yet in pig)
	Adult boars	Boars for service
	Piglets	Fattening swine under 20 kg
	Weaner pigs (under 20kg)	Fattening swine under 20 kg
	Weaner pigs (over 20kg)	Fattening swine 20-80 kg
	Finishing pig (porker)	Fattening swine 20-80 kg
	Finishing pig (cutter)	Fattening swine 80+ kg
	Bacon pigs	Fattening swine 80+ kg
	Barren sows for finishing	Barren sows for fattening >80kg
Sheep	Ewes	Adult ewes
	Replacement ewes	Shearling or replacement ewes (1+ years)
	Rams or tups	Adult rams or tups
	Lambs	Young sheep under 1 year
Other livestock		Goats
		Horses
		Deer (all)
		Chickens – layers
Other livestock (continued)		Chickens – broilers
		Breeding stock (all poultry)
		Pullets

Category	Category description
	Ducks
	TurkeysF
	Geese

Please see notes in our new Livestock Wizard or data collection spreadsheet for guidance on completing this section of the Calculator (including how to estimate average head of animals in each category over the 12 month reporting period). Emissions factors that the calculations are based on are determined by UK GHG inventory and its annexes (92) and IPCC methodology 2019 (94). Since the sex and age of the animal affects their metabolism, and therefore their enteric methane (CH4) emissions and excretion rate, livestock are separated by these characteristics in order to improve the estimates of GHG emissions, which are inherently variable. Lactation and pregnancy also alter an animal's GHG emissions so livestock are also separated based on this trait.

Within the Calculator, it is possible to simply enter only the average head of livestock in each applicable category for the most basic estimation of GHG emissions. In this case, where no liveweight is entered, a default liveweight is used (for categories of growing livestock, e.g. calves, this is a midpoint weight within the age-range, to take account of growth across the 12 month reporting period). These default values can be found in our data collection spreadsheet.

For a more comprehensive estimation of GHG emissions, we recommended creating multiple entries for each category with user-input liveweights - this will give a more accurate estimate of GHG emissions. Furthermore, by inputting information on dry matter intake (DMI) per head per year, users can improve the accuracy of GHG emissions estimation. Our new Livestock Wizard is designed to make calculating these averages easier for the user for a group of livestock.

A Tier 2 (UK-specific) methodology is employed to calculate livestock GHG emissions for cattle, sheep, and pigs. Poultry calculations undergo a Tier 2 calculation but with a zero value for enteric emissions while goats, horses and deer are treated with a Tier 1 (international) methodology.

In this way, the Calculator's Livestock section is customisable for a range of livestock production systems, whilst relying on the generic livestock categories underpinned by the IPCC and UK GHG Inventory guidance. Unfortunately, the IPCC guidelines do not currently incorporate a comprehensive GWP* methodology, and there is no consensus on it's use, so we as yet do not provide this as an option in the calculator.

Animal feeds

These indirect emissions are very important to assess the holistic carbon impacts of livestock production. The list is split into organic and non-organic feeds, as well as a list of generic and branded feed blends. 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' (18). 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 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.

The exceptions to these approaches are as follows:

Section	Item	Reference	Notes
Calf rearing	Whole milk powder	68	
	Milk replacement powders (all)	18, 67 & 68	Formulations of milk replacement powders taken from 67 and relevant emissions factors applied to constituent parts based on information in 18 and 68
	Calf rearing pellets	18 & 67	Formulations of milk replacement powders taken from 67 and relevant emissions factors applied to constituent parts based on information in 18.
Supplements	Novapro	72	Estimate of emissions associated with constituents of Novapro (factor to be reviewed upon acceptance of product into GFLI database)

Emissions factors are based on users entering tonnes of product used on an annual basis.

Animal bedding

Animal bedding materials emissions factors are taken from the Inventory of Carbon and Energy (ICE) database v3.0 (2a) 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.

7.7. 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 Landfill emissions, as well as composting and AD emissions are derived from BEIS GHG conversion factors (86).

7.8. 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 BEIS GHG conversion factors (86). 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).

7.9. 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:

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.

	Soil Organic Carbon		This is converted into changes in volume of soil organic carbon and therefore the amount of carbon sequestered (or emitted) as per IPCC methodology.
	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	58	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	58	Average values per hectare of types of woodland, over a 200 year average.
	In field trees	58	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.

7.10. Processing

This section calculates carbon emitted from food and drink processing, including manufactured inputs commonly used..

Data sources: All of the emission factors are proxy figures, but are all allied to quantities of inputs, not estimates of items used in a process.

Section	Item	Reference	Notes
Sugar	Cane & Beet	17	Proxy figures for cane sugar production
Fermentation	CO2 release	34	Direct CO2 released from the fermentation process
Processing products	*Various*	80	Proxy figures for processing input
	CO2 canisters	N/A	Enter the volume of CO2 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	86	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	86	Proxy figures for packaging input
	Corks	95	Proxy figures for packaging input
	Crates and Packaging	86	Proxy figures for packaging input
	Various	86	Proxy figures for packaging input
Refrigeration	Refrigerant usage	12	Refrigerant use and losses
Water	Mains water	86	Use of mains water
	Mains waste water	86	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.

8. 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.

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

Conversions from individual GHG emissions to CO2e

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 N2O emissions. The calculations provide a value for the quantity of N2O released, which we then convert into CO2e per N2O 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

9. What farm business information do users enter?

At the start of all carbon reports users are asked to input information about their farm business (or specific carbon report). This includes the following information:

1. **Business category** (multiple can be ticked) - 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

2. **Soil type -** Sandy/Light, Sandy Loan, Sandy Clay Loam, Sandy Silt Loam, Loam, Medium Loam, Clay Loam, Clay, Heavy Clay, Silt, Silty Clay Loam, Peat, Chalk

3. **Inventory method** - Determines whether the capital items are being accounted for upfront or whether the emission factor should be depreciated over a 10 year period.

4. **Certification** - Businesses can mark any certification or assurance schemes they were a part of.

5. **Farm area in hectares** for each of the following:
    - 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

6. **Carbon price** - an optional category for including the price a user is paid for any carbon traded, in £ per tonne of carbon. This will likely become more important in the future.

7. **Scope of study** - whether the report covers up to the farm gate only, also Distribution, or right up to the Point of Sale. It is important that reports make clear where the boundaries of reporting lie, especially for comparisons against other businesses.

8. **Overheads report** - users can create Overheads inventories for their business, which is used specifically when creating reports on a per product basis (e.g. wheat, milk., cauliflower) or where multiple enterprises share equipment or resources. User guidance is given on how to create Overheads and Produce basis reports.

10. Standards and compliance

We believe there is not currently a satisfactory national or international standard that covers the exact requirements of a farm carbon report. PAS 2050 is widely used to calculate the GHG emissions from various products and services. Its methodology is used in the Calculator, however its scope falls short of what is required for a complete farm carbon footprint, in that it doesn't include Scope 3 (indirect) emissions, and is very limited on carbon sequestration.

We are actively developing alignment with international standards such as ISO 14064 and the GHG Protocol, as well as land-sector based guidance from FLAG. We also closely follow developments in the standards adhered to by the International Dairy Federation.

11. What's new and what's not included

New developments for each cycle are listed here to enable users to see what's changed.

There are often good reasons why certain items are not included, and they usually relate to the lack of available peer reviewed data.

12. Independent Reviews

We believe it's important for any Carbon Calculator to be independently scrutinised. We aim to undertake this on an annual basis. Our last review was completed in December 2023 by The Carbon Trust.

13. Development cycle

Our development cycle is summarised in the figure below. At a minimum, the Calculator is updated annually. Research into new data, methodologies, and new user functions does continue throughout the year and minor adjustments may be made to the calculator.

As we develop the calculator, we believe it's critical to listen to the views, requests and questions of our users, ensuring we are as relevant, up to date and user friendly as possible. A structured engagement process with users and working groups on particular topics, helps to strengthen the knowledge, feedback, rigour and testing for the Calculator.

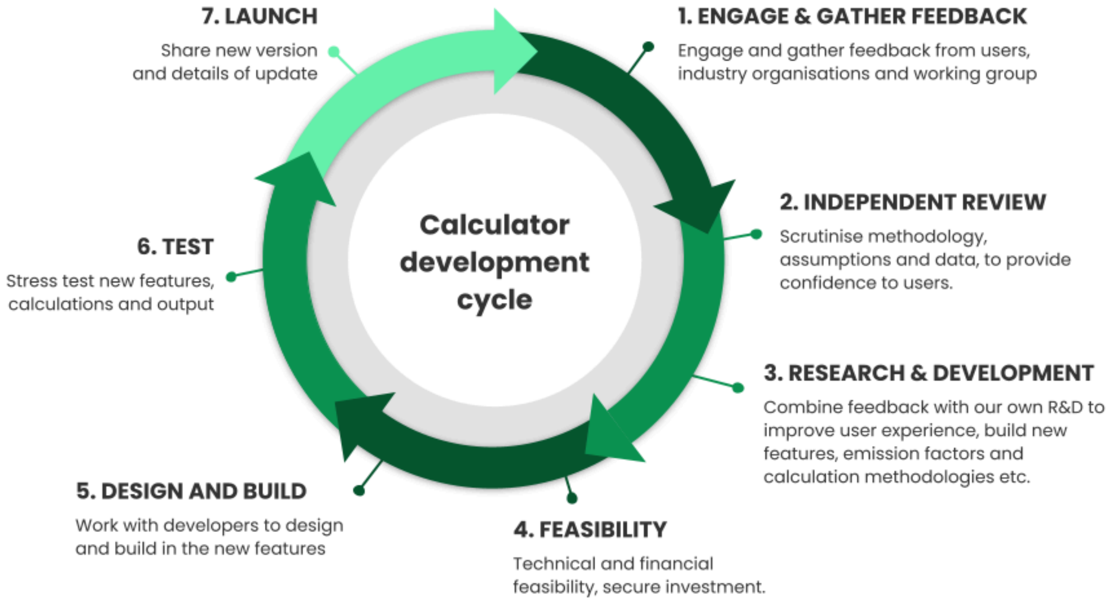

Figure: Our annual calculator development cycle

14. Contacting us

We welcome Calculator users to contact the Calculator team with questions, suggestions and comments at any time. **For all enquiries, please email: calculator@farmcarbontoolkit.org.uk**

Calculator Manager: Lizzy Parker

Calculator Development officer: James Pitman

Calculator Development officer: Grace Wardell

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