# Embedded Emissions from Purchased Livestock in Farm GHG Accounting

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# 0. Executive Summary

This white paper outlines the case for including embedded emissions from purchased livestock in farm-level greenhouse gas (GHG) assessments. It frames the proposed enhancements to livestock accounting methodologies in farm carbon calculators and sets out the required changes to ensure consistent, transparent, and robust reporting. The document establishes a shared understanding of the rationale, scope, boundaries, and methodological options for capturing the embedded emissions associated with the acquisition of live animals from external farms.

Three options are presented for the inclusion of embedded livestock emissions: option 1 using FAO GLEAM emissions intensity factors based on animal liveweight at purchase (recommended); option 2 looping method to create custom emissions factors for animals using calculator tools; option 3 enabling verified embedded emissions factors to be added to farm footprints. We recommend the implementation of option 1 immediately to correct the omission of purchased animal emissions, with a recommendation for eventual inclusion of option 3 as suppliers more closely record rearing emissions.

# 1. Introduction

Carbon Calculators for farms aim to provide robust greenhouse gas (GHG) assessments across a wide range of farming systems. As livestock enterprises frequently rely on animals purchased from other farms (e.g. replacement dairy heifers or calves reared off-farm), accounting for the embedded emissions associated with these animals is essential for accurate farm-level GHG footprints.

Currently, these embedded emissions are either underrepresented, excluded or inconsistently captured in most farm GHG tools. This omission can lead to:

- Underestimated farm footprints, particularly for farms relying on externally raised animals.
- Inconsistent comparisons between farms breeding their own replacements and those purchasing them.
- Misallocated emissions, particularly when emissions are not correctly assigned to sold animals.
- Missed mitigation opportunities along the supply chain.

This white paper outlines current limitations, assessment boundaries, allocation principles, and methodological options for incorporating embedded emissions of purchased livestock within such calculators.

# 2. What are Embedded Emissions?

Embedded emissions are indirect GHG emissions related to purchased or acquired goods and services, often referred to as scope 3 emissions. 'Upstream indirect emissions' and 'purchased livestock emissions' will be called embedded emissions in this paper.

For the farm purchasing or otherwise obtaining replacement animals or youngstock from another farm, the emissions associated with raising those animals to their purchased age/weight should be included as scope 3 emissions, thus accounting for purchase of livestock in an equivalent way to the purchase of other goods such as animal feeds.

We seek to estimate these emissions at a per kilogram of liveweight purchased level, filling a currently omitted section of livestock emissions accounting.

# 3. Why this paper is needed:

Currently, most farm emissions calculators omit the embedded emissions in the animals purchased onto farm, despite accounting for the embedded emissions in other purchased goods like feed and fuels.

As per the GHG protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI & WBCSD, 2011), companies shall include embedded emissions when reporting. The minimum boundary set by the standard is "All upstream (cradle-to-gate) emissions of purchased goods and services", which would include purchased animals. The International Dairy Federation (IDF, 2022) and the PEFCR for dairy (European Dairy Association, 2025) also state that any purchased resource should be included as a farm input and resource. This includes all ages of replacement: Dairy cows (dry and lactating), calves, young stock until 1 year of age and young stock over 1 year, and heifers. Despite this guidance, current farm GHG tools often exclude or oversimplify embedded emissions from livestock purchases (Figure 1), particularly those involving youngstock or replacements.

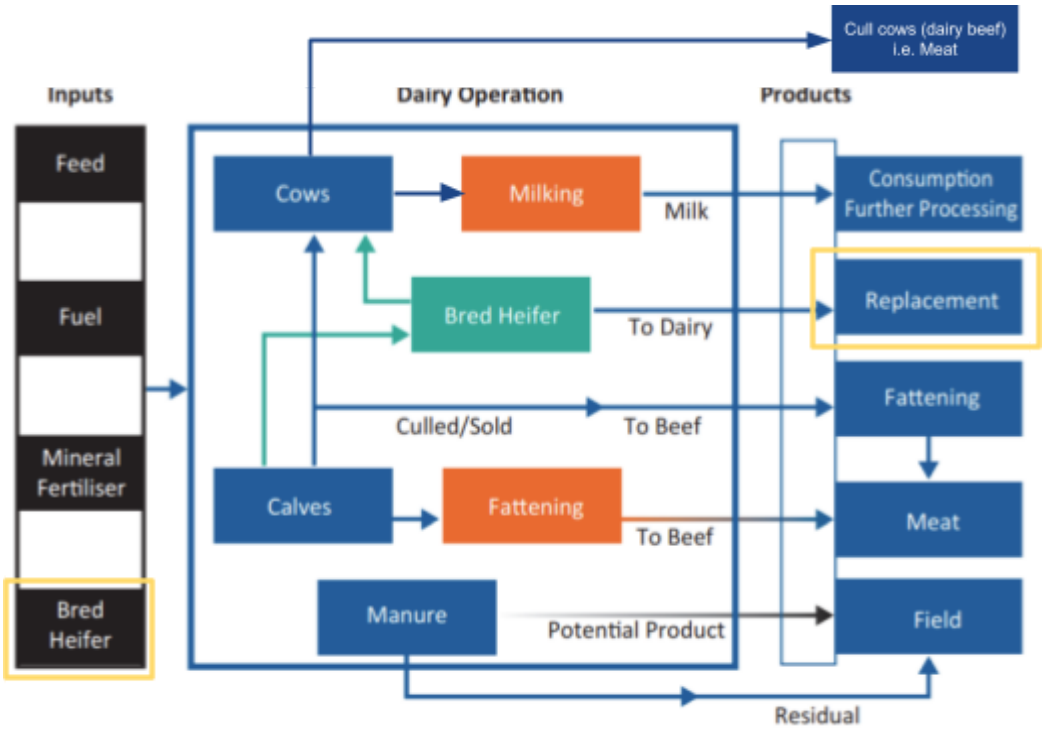


***Figure 1.*** *Processes and products from livestock operations (amended from IDF 2022), highlighted in the yellow boxes, are areas with embedded emissions that this white paper aims to address. Orange coloured boxes are separable enterprises already estimated widely within farm GHG accounting tools, green arrows represent internal flows that may not affect allocation calculations.*

# 4. Scope and Assessment Boundary

The methodology presented here can be standardised and utilised across farm and product footprints if the following framework is used:

- **Assessment Boundary: Cradle-to-farm gate**
    - Only embedded emissions (Scope 3) related to animal production until the point of farm entry are considered.
- **Apply this methodology to**: Purchased live animals (e.g. calves, heifers, lambs).
    - This includes flying herds, replacements and animals bought to establish new herds / flocks - All purchased animals should have embedded emissions included.
- **Do not apply this methodology to**: Animals originating on farm & mortality
    - **Animals born on farm** - additional emissions from gestation accounted for in accounting for mother's increased energy requirements
    - **Animals that die within the reporting period** - this is accounted for as wastage within the existing tools (i.e. emissions from the animals while alive are accounted for and indirectly increase the emissions of milk/ meat production).

# 5. Methodological Options

Calculating the embedded emissions for purchased livestock can be done at varying levels of detail depending on the data input, the calculation capability, and the factors available. Below three options for establishing embedded livestock emissions factors are presented.

### Option 1: External Emission Factors (Adjusted from FAO GLEAM)

*Overview*: Use regional, system-specific FAO GLEAM (https://www.fao.org/gleam/en/) factors for different animal categories (e.g., beef, dairy, feedlot etc.), and apply them on a per kilogram of liveweight purchased basis. The factors are created from the allocation of animal emissions to core products (e.g., meat, milk, wool), acting as default functional units for the different animal categories (i.e. kg$CO_2$e / kg liveweight). This is the recommended option for most use cases due to its simplistic, repeatable and reliable implementation.

*Emissions factors*: The FAO GLEAM interface provides emissions factors for Cattle, Buffalo, Sheep, Goats, Pigs and Chickens across 22 global regions (see Annex A1 for data details). The emissions factors take into account 11 separate components (table 1) with the emissions presented as per AR6 reporting standards.

*Table 1: Example of the FAO GLEAM emission per kg of liveweight for cattle and sheep in Western Europe. Blank cells represent no data given. Components are split by gas, but values are presented in kg$CO_2$e as per AR6.*

| **Animal** | | **Cattle** | **Cattle** | **Sheep** | **Sheep** |
|---|---|---|---|---|---|
| **Production system** | | **Grassland** | **Mixed** | **Grassland** | **Mixed** |
| Direct on-farm energy | $CO_2$ | 0.040 | 0.040 | 0.212 | 0.148 |
| Embedded on-farm energy | $CO_2$ | 0.125 | 0.153 | 0.094 | 0.091 |
| Enteric fermentation | $CH_4$ | 3.168 | 2.886 | 2.759 | 2.281 |
| Feed | $CH_4$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Feed | $CO_2$ | 0.374 | 0.572 | 0.108 | 0.218 |
| Feed | $N_2O$ | 0.684 | 0.825 | 0.433 | 0.339 |
| LUC: pasture expansion | $CO_2$ | 0.000 | 0.000 | 0.000 | 0.000 |
| LUC: soy and palm | $CO_2$ | 0.056 | 0.105 | 0.010 | 0.044 |
| Manure | $CH_4$ | 0.459 | 0.660 | 0.047 | 0.111 |
| Manure | $N_2O$ | 0.471 | 0.765 | 0.111 | 0.507 |
| **Grand Total** | **$CO_2$e** | **5.378** | **6.006** | **3.773** | **3.740** |

*Application approach*: Below is the basic equation to be used in option 1. It is advised to group animals by liveweights and enter each group separately to ensure an accurate average weight.

$$L^{Embedded} = EF^{LW} \times LW \times Head$$

Where, $L^{Embedded}$ is the total embedded emissions for purchased livestock ($kgCO_2e$); $EF^{LW}$ is the FAO GLEAM emissions intensity factor per kilogram of liveweight ($kgCO_2e$/kg liveweight); LW is the average purchased animal liveweight (kg); and Head is the total number of the animals purchased.

*Advantages*:

- Simple to implement.
- Based on peer-reviewed LCA data.
- Readily available and citable open source data.

*Disadvantages*:

- Limited animal or system specific considerations: Ignores age, sex (i.e. herd category), and refined management system differences.
- For species that *can* produce co-products, there is no differentiation between enterprises that do or don't produce said co-product. $EF^{LW}$ is calculated post-emissions allocation between coproducts from a whole region. This means using these EFs may underestimate emissions when purchasing animals from enterprises that only produce meat. For example, if a beef finisher purchased steers from a beef breeder system $EF^{LW}$ would underestimate the steers' embedded emissions as that EF assumes the steers come from a system with some dairy production.
- Requires assumption of linear emissions across life.

*Worked example*: A Danish farmer purchases 6x grass fed steers with a purchased weight of 245kg. Take the GLEAM factor for Western Europe grassland raised cattle (5.378 $kgCO_2e$/kg Liveweight) and multiply by the kilograms of liveweight purchased to get the total embedded emissions for the purchased cattle (7,905.66 $kgCO_2e$).

## Option 2: Looping Method (Internal Estimation)

*Overview:* Assuming the purchased animals are produced in the same way as the group of animals being footprinted, the lifetime emissions of a representative animal are modelled. This generic emissions intensity is used to impute the embedded emissions for an animal at a specific age and weight at purchase.

*Advantages*:

- Enables consistency between purchased and sold animal footprints.

*Disadvantages*:

- Assumes the purchasing and selling farm are similar
- Requires assumptions about growth rates and net energy values.
- Linear unless further developed.
- Tool-calculated value; so any inaccuracies and/or differences in methodologies get amplified.

*Worked example [livestock category present on purchasing farm]*: Using a farm carbon calculator, a farmer has calculated that his 100% outdoor grass fed calves produce 1696 $kgCO_2e$ per head per year. He then purchases a further 3 calves at 12 months old that were reared off-farm. For each of these calves he uses the 1696 $kgCO_2e$ as the emissions factor since they are 12 months old. The looping method assumes that he purchases calves raised in the same way as his own cattle are raised.

*Worked example [no equivalent livestock]*: Using a farm carbon calculator, a farmer has calculated their pig finisher system has an emissions intensity of 4.33 kg $CO_2$e/kg deadweight. Based on their average dressing % (75%), this gives an emissions intensity of 3.25 kg $CO_2$e/kg liveweight. If the average purchase weight of gilts for the farm is 215 kg, and 263 of these animals are purchased in the reporting year, then the embedded emissions from this class of animals would be 183,771.25 kg $CO_2$e (3.25 x 215 x 263).

### Option 3: Custom Emission Factor

*Overview*: Enable users to enter verified, supplier-specific emission factors for purchased livestock. This is primarily a functionality rather than a methodological approach, and requires the supplier to have recorded the emissions produced in rearing the livestock being sold.

*Advantages*:

- Enables farm-specific differentiation.
- Encourages upstream transparency and data-driven decision-making.

*Disadvantages*:

- Data is not always available.
- Risk of inconsistent data quality.
- Expensive for farms and supply chains to verify and skills / capacity of verification lacking at scale.

*Worked example*: A beef stock breeder records the life cycle emissions from the youngstock they produce, assigning a total of 3456 kg$CO_2$e to each of the 18 month old steers reared in a 50% supplemented pasture and 50% silage fed deep bedding system. A farmer purchases 6x of the youngstock, and has to enter these as an additional step to his farm footprint, adding a separate 20,736 kg$CO_2$e scope 3 emissions to the farm footprint.

# 6. Key Assumptions

The three options for implementation are built upon the following assumptions:

1. **Emissions accumulate linearly** across an animal's life and between life stages.
    a. Later iterations may include **non-linear growth/emission models**.
2. **Transport of purchased animals to the farm** is **a separate Scope 3 component**. It is not included in the assumptions of the methods outlined here (which consider embedded livestock emissions to farm gate of producer).

# 7. Examples of systems that will use this method

To demonstrate the impact including embedded emissions will have on farms, we present worked examples below of how implementing option 1 (FAO emissions factors) changes a farm's emissions footprint.

Below are examples of UK farm business GHG emissions with and without the inclusion of embedded livestock emissions calculated using the Farm Carbon Calculator (Table 2).

*Table 2: the impact of including embedded livestock emissions on farm footprints using the Farm Carbon Calculator methodology (version 3.4).*

| **Enterprise Overview** | **Purchased animals** | **Farm emissions without embedded emissions (current)** | **Farm emissions with embedded emissions (proposed)** |
|---|---|---|---|
| Finishing farm, purchasing low weight beef youngstock for fattening, and ewe lambs for expanding breeding flock. | 500x Beef stores (185kg), 100x Ewe lambs (40kg) | 3,745.87 $tCO_2e$ | 3,745.87 + 497.47 [Stores] + 13.51 [Lambs] = 4,258.44 $tCO_2e$ |
| Broiler farm with its own arable production. | 2.2million day old chicks (40g) annually. | 35,318.35 $tCO_2e$ | 35,318.35 + 50.51 [Chicks] = 35,368.86 $tCO_2e$ |
| An upland Beef and Lamb producer breeding its own replacements. | 0, all on farm origins. | 829.80 $tCO_2e$ | 829.80 $tCO_2e$ |

Below is an example of how a farm footprint using the Cool Farm Alliance platform would change with the inclusion of embedded emissions (Table 3).

| *Table 3: the impact of including embedded livestock emissions on farm footprints using the Cool Farm Alliance methodology (version 3.0).* | | | |
|---|---|---|---|
| **Enterprise Overview** | **Purchased animals** | **Total dairy footprint without embedded emissions (CFP methodology v3.0)** | **Total dairy footprint with embedded emissions (proposed methodology)** |
| Sells all calves as stores and purchases replacement dairy heifers | 30 dairy cows and 11 dry cows, 30 calves sold, 10 heifers purchased | 243.7 $tCO_2e$ | 271.3 $tCO_2e$ |

Below is an example of how a farm footprint using the Agrecalc platform would change with the inclusion of embedded emissions (Table 3).

| **Enterprise Overview** | **Purchased animals** | **Enterprise emissions without embedded emissions (kg $CO_2$; current)** | **Enterprise emissions with embedded emissions (kg $CO_2$; proposed)** |
|---|---|---|---|
| Poultry finisher that buys in broiler chicks | 199,500 chicks purchased at 0.04kg, 189,525 finished broilers at 2.20 kg, with a dressing % of 72% | 1,029,712 | 1,050,726 (using option 2) |
| Sheep finisher system that buys in gimmers for breeding | 70 gimmers purchased at 56kg | 322,771 | 337,906 (using option 1) |

# 8. Recommendations

Embedded emissions from purchased livestock are currently excluded from most farm footprints, and therefore we outline some key recommendations for those creating farm footprints that want to include scope 3 emissions.

- Implement **Option 1** immediately using FAO GLEAM with region/system disaggregation (see annex 3 for raw data, or visit FAO GLEAM https://gleami.apps.fao.org/)
- **Be consistent** with system boundaries, e.g. when a calf is considered to move from dairy to beef, and with scopes reporting.
- Ensure animal **purchase and sale** data fields are robustly recorded in the tool, including age, weight, category, and source.
- Consider implementation of option 3 for those users who have reliable data available from their suppliers

# 9. References


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