A BRITISH FREE RANGE EGG PRODUCERS ASSOCIATION SUSTAINABILITY SCHEME REPORT

NET ZERO AND ENVIRONMENTAL SUSTAINABILITY IN FREE RANGE EGG PRODUCTION

PHASE 1 REPORT TO BFREPA

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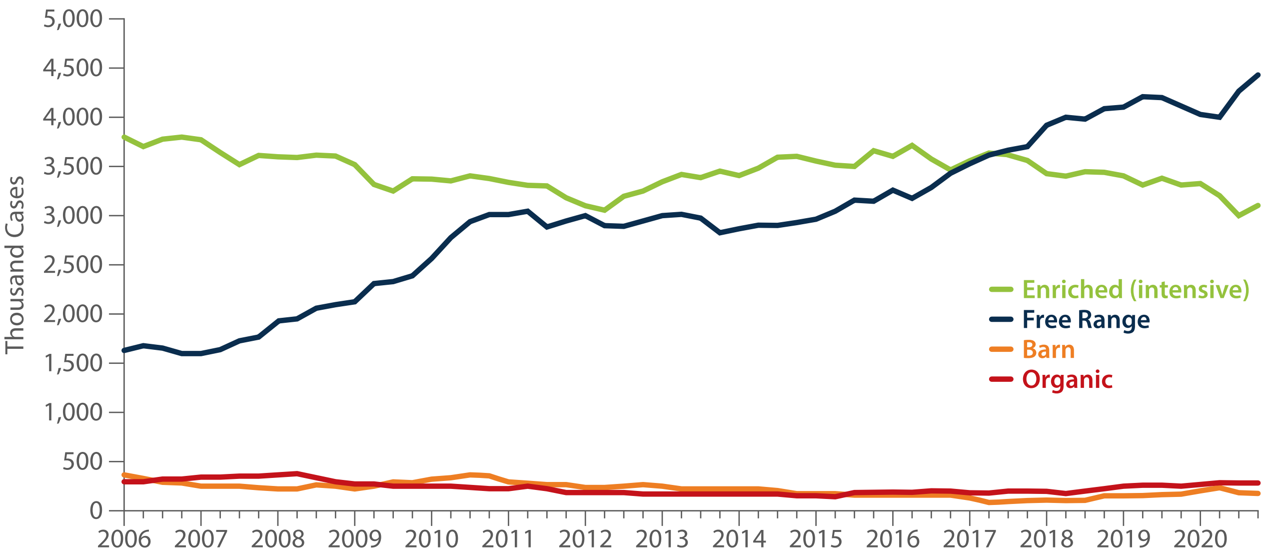
1 INTRODUCTION AND PROJECT SCOPE

Information on the sources and magnitudes of greenhouse gas emissions from livestock food production is of considerable and growing interest to policymakers, industry and consumers.

This is now also driven by Government targets to transition to a low carbon, net zero economy by 2050. Emissions from red meat production are relatively well understood but information on the emissions associated with UK free range egg production is limited to studies of partially comparable US intensive systems, or examples from Europe and Australia. A recent review of the sustainability of egg production in the UK highlighted these gaps in our understanding[1]. In particular, the authors noted that because each type of production system (free range, organic, barn, enriched laying cage) has a characteristic pattern of emissions and impacts, sustainability assessments should be tailored to suit each system.

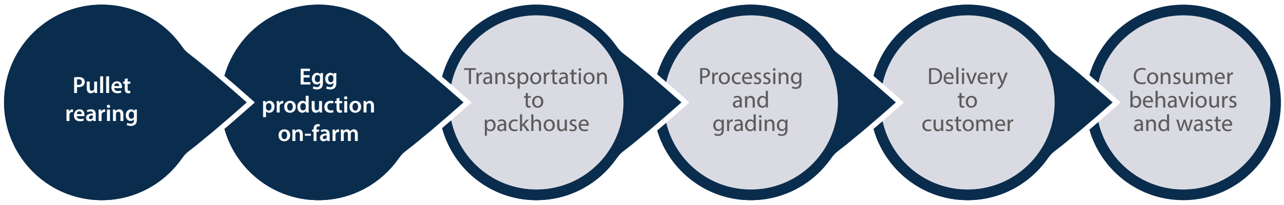
This project investigates opportunities for net zero and environmental sustainability within the UK's free range egg production sector. Free range egg production accounted for 56% of throughput during the last quarter of 2020 in the UK and remains the fastest growing production system of the egg industry (Figure 1)[2].

Figure 1 – UK egg throughput by production method[2]



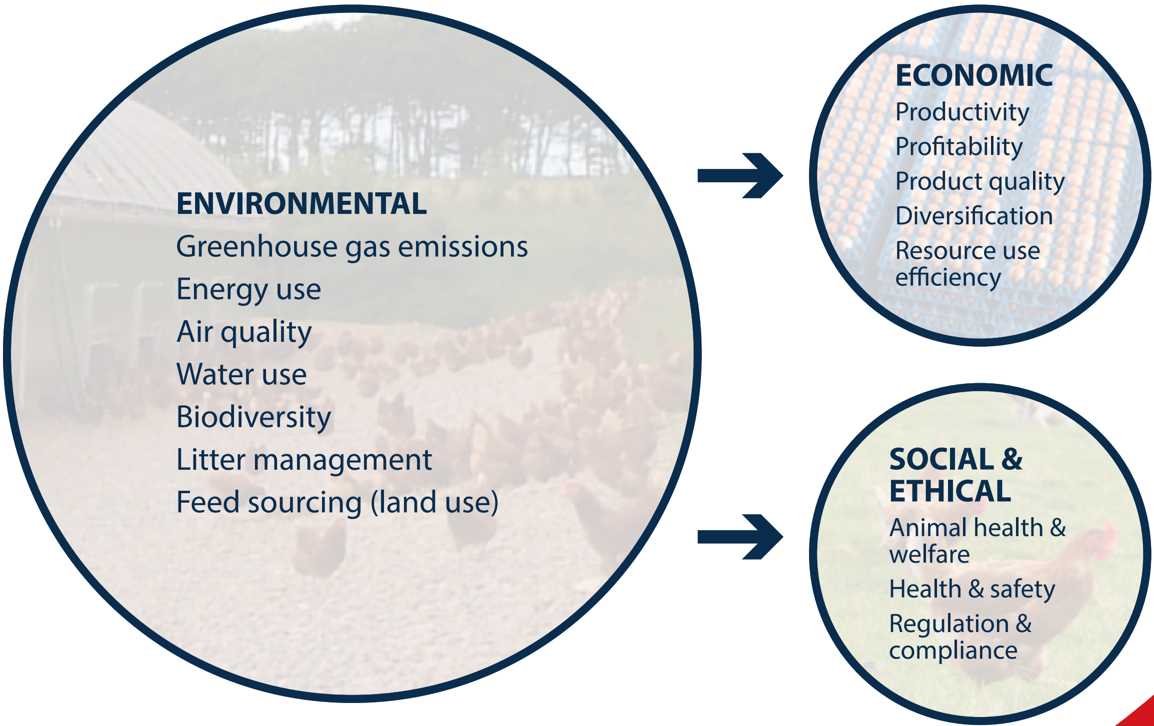
The scope of the emissions and environmental sustainability assessment of free range egg production is important to define. For the purposes of this project, the scope is defined as farm gate impacts only as demonstrated in Figure 2 below. Impacts and emissions post farm gate from transportation, grading and packaging at packhouses, retails sales and consumer behaviours and food waste are not part of this study.

Figure 2 – Project scope within the supply chain



Sustainability encompasses three main dimensions of economics, social and ethical, and environmental considerations. The first phase of this project has considered key themes within environmental sustainability only, mainly greenhouse gas emissions but also ammonia and air quality, water security, biodiversity, litter management, feed sourcing and energy use (Figure 3). The second phase of the project will include consideration of economic and social themes of sustainability.

Figure 3 – Focus of phase 1 and environmental sustainability themes



2 APPROACH AND METHODOLOGY

A desktop literature review was conducted to capture current studies and insight on environmental sustainability within the UK free range egg production sector.

Similar studies were found from the Netherlands, America and Australia and where relevant, findings are presented throughout the following sections of the report. A UK study in 2014 by Taylor et al commented that there are gaps in our understanding of sustainability within free range egg production in the UK as the few studies available are based on structural models[1,3].

To assist in filling these knowledge gaps, and to provide a UK context to the sustainability principles used, the project approach included engaging with two pilot farms. The two farms participated in data collection and surveys to review net zero and environmental sustainability practices within free range layer units. Farm 1 was a multi-deck unit with two sheds of 32,000 hens in each (64,000 hens total). Farm 2 was a flat deck system with 12,700 hens in total in one shed. Both farms use the same pullet rearer and feed supplier.

The first stage of the project was to define a reference period for each farm. When calculating greenhouse gas emissions, carbon footprinting tools and sustainability assessments are usually based on a 12 month reference period, either a calendar year (e.g. 2020) or financial year (e.g. April 2019 – March 2020). For this project, data was collected using the farm's most recent completed flock cycle as the reference period. Matching data inputs to flock cycle length enabled easier data collection for the producers, especially when requesting information from feed suppliers or packhouses. The data collected was then annualised to calculate emissions from each farm per year.

Data was collected during two meetings with each farm, one online and one in person at the farm. A data input sheet was shared with each producer to enable easier data collection and Promar staff assisted to fill any gaps during farm visits and interviews. For mixed farms (farms with layer units plus additional enterprises such as livestock or arable) it was important to only include data specific to the layer unit. Data inputs such as energy use or diesel use were split proportionally based on business turnover where specific data per enterprise was not available. Anecdotal evidence of wider environmental sustainability practices associated with ammonia, water use, biodiversity and litter management and feed was captured in a survey conducted on farm with producers.

Greenhouse gas emissions for both farms were calculated using the Eggbase carbon tool. The Eggbase tool is newly available for egg producers after four years of development. The tool offers a full integration for existing Eggbase clients as an additional module, or can be used as a one-off end of flock cycle carbon footprinting tool for a small fee.

The Eggbase carbon footprint calculations allow for[4]:

- Full transparency and audit trail of carbon footprint figures
- Individual flock or crop carbon footprint
- Carbon footprint benchmarking across all your flocks
- Carbon footprinting across supplier groups of pullet rearers, egg layers or broiler growers
- Assessment of the effect of changes in feed or other aspects of production on the carbon footprint
- Easy remote collection of carbon footprint data by packers, retailers, feed suppliers or breeders

There are many other freely available carbon calculators available online for producers to utilise, some key points of difference of the Eggbase calculator include:

- Emissions from pullet rearing are included in the Eggbase carbon tool. Often, no published production data is available for the emissions associated with the production of pullets however Eggbase estimates pullet rearing can account for between 5 – 15% of farm gate emissions.

- More accurate emission values for feed is used in the Eggbase carbon tool based on a Tier II IPCC methodology. A specific emissions value for each ration based on raw ingredients and source country of origin has been developed in consultation with the main feed suppliers under non-disclosure agreements. Other online tools may use standard values in a Tier I IPCC methodology and therefore may risk underestimating emissions from feed.

- Additional inputs of water and medical (veterinary supplies etc) are included in the emissions calculated using the Eggbase tool which are commonly not included in other online tools.

3 NET ZERO IN FREE RANGE EGG PRODUCTION

Net zero targets focus on lowering greenhouse gas emissions from agricultural activities, then offsetting residual emissions that remain, thereby reaching carbon neutrality. Emission reduction should be the priority and there are many strategies producers can explore to lower the carbon footprint of free range egg production.

The first step towards net zero is to calculate emissions from the layer unit to understand the key sources of emissions and to set a benchmark from which progress can be measured against. Producers can then explore how best to reduce emissions before investigating offsetting options.

3.1 TOTAL EMISSIONS PER FARM

The greenhouse gas emissions (or carbon footprints) for each farm are shown in Table 1 below. Total farm emissions provide a useful benchmark for individual farms to use to monitor change over time on their farm, but should not be used to compare against other layer units. Total emissions from Farm 1 was calculated as 4,827,033 kilogramme (kg) of carbon dioxide equivalent emissions (CO2e) per year, and Farm 2 was 973,830kg CO2e/year. Total emissions from Farm 1 are higher due to the larger scale of the layer unit at this farm of 64,000 hens compared with 12,700 hens at Farm 2.

Reporting emissions per kilogramme of eggs produced (emissions intensity) provides a comparable result between farms as it incorporates the level of production achieved and reflects a level of efficiency at each farm. The results using the Eggbase carbon calculator show Farm 1 emits 3.01 kg CO2e per kg of eggs produced, while Farm 2 emitted 3.44 kg CO2e/kg eggs (Table 1).

Table 1 - Carbon footprint results

	Total emissions (kg CO2e / farm)	Emissions intensity (kg CO2e / kg eggs)
Farm 1	4,827,033	3.01
Farm 2	973,830	3.44

Table 2 below shows the total emissions by category to provide more detail and to highlight the different sources of greenhouse gas emissions from layer units.

Table 2 - Total farm emissions by category from the Eggbase carbon tool

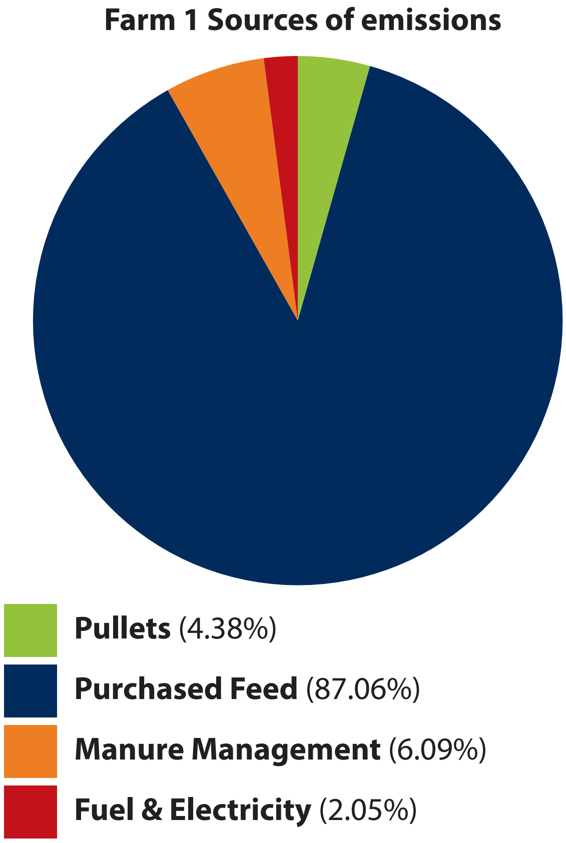
	Farm 1 total emissions (kg CO2e/year)	Farm 2 total emissions (kg CO2e/year)
Electricity	26,132	9,232
Other fuels	62,022	4,635
Feed	3,732,135	864,792
Litter	2,747	579
Manure	260,922	51,776
Medical / Veterinary	13,736	2,897
Water	1,607	321
Pullets	187,730	39,598
TOTAL EMISSIONS	4,287,033	973,830
Emissions per kg eggs	**3.01**	**3.44**

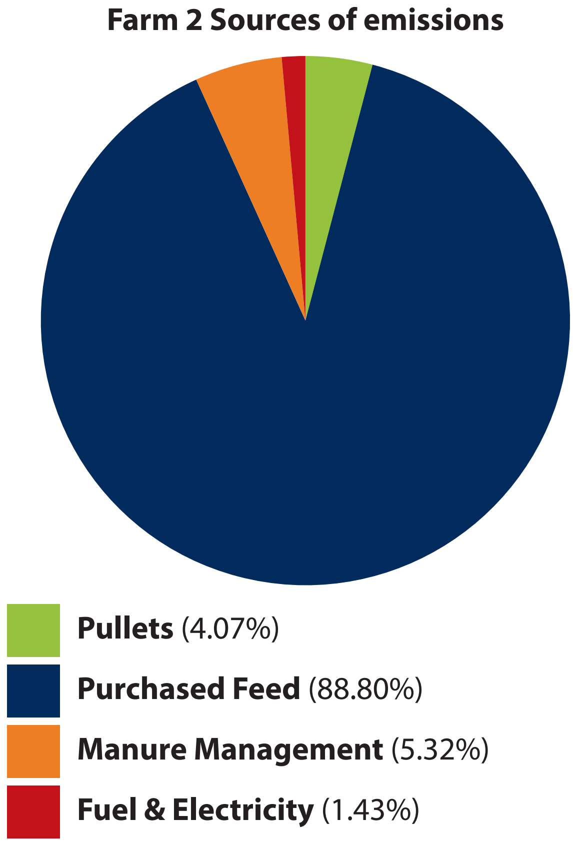
The sources of emissions from both farms are presented below in Figure 4 and include purchased feed, manure management, fuel and electricity and pullet rearing. Not shown on the charts are emissions from litter, water and medical/veterinary which comprise less than 0.05% of each.

Figure 4 shows that the largest contribution of greenhouse gas emissions from both farms is feed. Feed imports to farms attracts a high embedded carbon footprint as it is grown, processed and transported to the farm with all stages resulting in emissions to the atmosphere. The two next largest contributions result from manure management and pullet rearing, followed then by fuel and electricity usage.

Manure emissions are associated with calculated excretion rates of the hens, nitrogen (in crude protein) content of the feed ration, amount of volatile solids in manure, and the manure storage practices on farm. Manure from sheds fitted with manure belts tend to have higher levels of

Figure 4 – Sources of greenhouse gas emissions on free range poultry units





residual carbon and nitrogen, suggesting that losses are lower[5]. Manure emissions are accelerated by high moisture, wetting/drying and anaerobic conditions plus ventilation rate, manure moisture content, air temperature, and stacking profile[6]. Emission factors from manure management are also higher for longer residence times[7]. After manure is removed from the shed it is stored or transported to the field for application. All farms aimed to minimise manure storage time on-farm. However, in some months of the year demand for manure is low and storage for periods of 1-3 months may occur.

3.2 STEPS TO ACHIEVE NET ZERO

When transitioning to net zero free range egg production, there are two main steps for all producers to consider:

1) Reducing emissions from the farm

2) Offsetting residual emissions through carbon sequestration activities on farm

Emission reduction should always be the first priority to mitigate against greenhouse gases entering the atmosphere. Strategies for emission reduction are included in Section 3.2.1 below. Offsetting the residual emissions that remain after emissions have been reduced as much as possible can be used to achieve net zero (or carbon neutrality). Activities that help increase carbon sequestration on farm have other environmental benefits and are presented in Section 3.2.2.

3.2.1 EMISSION REDUCTION STRATEGIES

The results from the two pilot farms identified the main greenhouse gas emitted from poultry units is carbon dioxide. This differs from other agricultural sectors such as cereals where the main greenhouse gas emitted is nitrous oxide, and the red meat livestock sector where the main greenhouse gas emitted is methane, especially from ruminants. Carbon dioxide emissions are associated with the embedded emissions in feed and emissions from fossil fuels used in electricity use and transportation. Emissions from nitrous oxide result from manure management practices and methane emissions also result from manure storage in anaerobic conditions.

When targeting emission reduction activities through changes in land management practices or investments in infrastructure, the largest gains will be achieved by addressing the principal sources of emissions. Emissions from feed are the largest source of free range egg production's carbon footprint, comprising 80 and 85% on the two pilot farms.

Laying poultry diets typically contain 16% to 19% protein and the main source of protein often comes from soya. Soya meal imported into the UK comes primarily from South American countries such as Argentina, Brazil and Paraguay[8]. Imported soya meal from these areas can attract a very high carbon footprint of 9 kg to 15 kg of CO2e / kg due to significant emissions from land-use change (Carbon Trust, 2010). The UK is now able to import soya with a higher protein content (Hi-Pro) from the US which helps to avoid these land use change emissions.

Reducing the reliance on imported raw ingrediants and specifically proteins is a very strong lever available to free range egg producers to lower emissions. Alternative protein sources for poultry may emerge as innovations in feed become readily available and more cost effective including:

- Worms (Lumbricus sp.) produced by composting organic wastes
- Algae produced in biological systems for industrial exhaust emissions

- Processed animal by-products from red meat production
- Insect larvae
- Lupins

All of these alternative feeds have the theoretical potential to be incorporated into poultry diets however more work is needed to ensure their economic feasibility[6]. Initial estimates based on feed formulation modelling using IPCC emissions data and replacing soya with these alternative protein sources, indicated a potential 60% reduction in the emissions footprint for poultry diets[1]. Incorporation of all or some of the alternative materials above should be considred against the economic impact for producers and must still allow for the nutritional objectives for the feeds to be achieved without increasing the cost of producing feed for poultry.

Producers often feel that emissions associated with the ration fed to their flock is largely outside of their control as feed suppliers determine what is available, the raw ingredients included and where the feed is sourced from. It is crucial going forward that feed suppliers and mills are part of net zero discussions to leverage real gains in emission reductions from feed. Involving a wider part of the supply chain will be essential in the journey to net zero.

There are other options producers can consider to reduce emissions at farm level to tackle the 15 – 20% of emissions that aren't associated with feed. These options are summarised in the following table and are focused on system design and husbandry practices leading to productivity improvements (Table 3). There is no one silver-bullet solution. Transitioning to net zero will require producers to implement a range of practices that result in incremental emission reductions. These reductions over time will then accumulate to result in large gains towards net zero.

Table 3 – Emission reduction options and strategies for free range poultry[1]

Option / Strategy	Potential emission reduction	Comments
Covering litter and manure storage	2.5% – 3%	Prevents direct emissions of nitrous oxide and methane during storage
Reducing layer casualties to less than 8%	0.5% – 2%	Increases number of productive birds during flock cycle. The same total emissions are allocated to greater production volumes lowering emission intensity
Increase laying rates by 5%	5%	The same total emissions are allocated to greater production volumes lowering emission intensity
Prolong flock laying cycles	2% – 5%	Increases productive life span of hens allowing for total emissions to be allocated over a longer flock cycle length
Closely review and monitor protein content in rations and aim to reduce if possible	1% - 5%	Unused protein lost in hen manure increases risk of nitrous oxide emissions from manure storage and application
Installing renewable energy capture and storage on farm (batteries)	2% – 4%	Removes emissions from fossil fuels associated with purchased energy use from the grid
Exporting manure to a anaerobic digester	5% - 7%	Removes both direct and indirect emissions of nitrous oxide associated with storing and spreading manures

3.2.2 CARBON SEQUESTRATION TO OFFSET EMISSIONS

To draw down carbon from the atmosphere (carbon sequestration) and to increase the amount of carbon stored on farm, producers have two main options to consider. The first is to increase the quality and quantity of perennial woody biomass on the farm through tree planting activities or by increasing the width and length of hedgerows. The second option is to invest in soil health to increase organic matter and organic carbon in soils.

Tree planting on ranges and other areas of land on the farm have multiple benefits such as:

- Providing habitat for native species
- Helping to regulate the flow of water across sloped fields,
- Protecting the river corridor and creating riparian habitat
- Acting as a barrier that helps absorb ammonia emissions from sheds
- Providing groundcover to protect the soil from erosion
- Providing shade and shelter to encourage hens to range wider
- Increasing the amount of carbon stored on farms helping to offset emissions

Farm 1 has a newly planted coniferous and broadleaf woodland of 27 ha in size which includes new plantings inside the range. The new woodland area has been validated and registered by the Woodland Carbon Code. The 100 year project is estimated to sequester 6,351 tonnes of carbon dioxide equivalent units over the project lifetime. The rate of carbon sequestration will be verified again at year 5, in 2024, and may result in the generation of carbon credits for this farm to use to offset residual greenhouse gas emissions from the layer unit.

Assuming a linear rate of carbon sequestration, this woodland is predicted to store 63.51 tonnes of carbon each year on the farm. The farm currently emits 4,827 tonnes of carbon per year so although the new woodland does not quite offset 100% of the farms emissions, it offers measurable carbon gains on this farm.

Elsewhere on the farm, the majority of hedgerows that border the range have been widened to encourage local habitat provision linking areas of woodland together. The grassland within the range is species-rich with a diverse variety of grass and herbal species.

Farm 2 has 31% (2.5 ha) of the range planted with trees, the majority of which are aged between 5 - 10 years. The species mix is broadleaf and coniferous and these trees are providing multiple biodiversity, carbon and welfare benefits. Surrounding the layer unit on this mixed farm is a large area registered under Countryside Stewardship further enhancing biodiversity throughout other areas of the farm.

Depending on the species planted within the Countryside Stewardship area and on the range, trees will sequester the most carbon between the ages of 10 to 45 years after planting, where sequestration rates may be in excess of 12 tonnes of CO2e per hectare per year[9]. If a farm has a policy of continual tree planting you ensure that there are always trees in the age-classes that maximise sequestration rates and draw down maximum amounts of carbon from the atmosphere.

4 ENVIRONMENTAL SUSTAINABILITY

To consider wider aspects of environmental sustainability beyond greenhouse gas emissions and net zero targets, themes such as water and energy efficiency, ammonia mitigation, litter and manure management and feed sourcing are addressed in this section.

4.1 ENERGY EFFICIENCY AND RENEWABLE ENERGY

An earlier study by Cranfield University and Defra reported that free range egg production can have up to 15% higher energy use requirements than caged systems[10]. It is therefore important that free range producers operate with energy saving and energy efficiently goals to reduce energy usage.

Both farms have invested in solar panels to generate energy for on farm use. Farm 1 has solar panels contributing 16% (31,725 kWh) of total energy demand. The business has recently completed an energy efficiency review which has outlined opportunities to expand solar coverage upon the sheds. Farm 2 has solar panels contributing 36% (19,534 kWh) of total energy demand. Further improvements in technology and in particular battery storage may enable farms to become self-sufficient in energy usage. Both farms have also implemented energy efficiency measures such as timed lighting systems, motion sensors and LED bulbs which all assist in lowering total energy usage.

4.2 WATER QUALITY AND SECURITY

Water quality and security of supply are essential for all laying units and there are many options available for producers to consider. Farm 1 stores water in tanks replenished by bore water supplies. Bore water is treated before use by hens in nipple drinkers resulting in low water usage of 2.1 litres of water per kg of eggs. Bore water is not metered on Farm 1 therefore usage is estimated. Mains water is available as a backup ensuring 100% water security.

Dirty water from shed washings are stored in below ground tanks which are then pumped out and taken off site. The new tree plantings of the range have assisted in slowing the flow of water across the range in high rainfall events leading to no evidence of active soil erosion. The recent addition of a reedbed drainage system ensures that pollutants are captured and filtered on the farm protecting the water quality of the surrounding catchment and lowering potential risks of water pollution.

The primary water supply at Farm 2 is mains water. The farm also has additional sources of water supply, including a well and rainwater harvesting capturing rainfall from roofs. Mains water is the only source of drinking water provided to hens through nipple drinkers and this does not require treatment on farm. Water usage at Farm 2 totals 3.9 litres per kg of eggs.

Dirty water from washing down the shed is allowed to disperse over the range, down into a soakaway and barrier ditch system prior to reaching a stream. This system helps to ensure risks of water pollution are minimised as the soakaways and ditches work to catch, filter and clean the water using natural solutions acting as a buffer before the water enters the main stream.

4.3 AMMONIA AND AIR QUALITY

The poultry sector is responsible for around 15% of the total ammonia emissions from agriculture in the UK, due to emissions from poultry houses, manure storage and applications of manure to land[11,12]. Defra's Clean Air Strategy and guidance document Code of Good Agricultural Practice for Reducing Ammonia Emissions (COGAP) has set high standards for poultry units to reduce ammonia emissions including guidance on housing systems, feed and diet formulation, and storage and spreading of manures. The European Commission set out a Best Available Technique (BAT) document outlining the requirements for production systems with 40,000+ bird places to comply with associated emission levels for ammonia (AELs). Though the actual BAT-AEL value varies according to species and housing system, the BAT conclusions set benchmark AEL values for laying hens in non-cage systems as a range of 0.02 to 0.13kg of ammonia per animal place per year [11,13].

Farm 1 being a newly constructed multi deck system has several ammonia mitigation measures in place including mechanical ventilation systems and manure belts that increase manure removal frequency and reduce ammonia emissions[6]. The farm currently does not have any air scrubbers, staged air cleaning systems or bioscrubbers as there are questions over the effectiveness of air cleaning in free range systems, because untreated air would be able to escape from the building through the popholes, when they are open[13]. Farm 2 as a flat deck system was constructed before such strict ammonia mitigation and planning controls were required.

The Centre for Ecology and Hydrology (CEH), and Forest Research Agency (FR) have developed a calculator and guidance for producers so they can maximize the benefits of planting tree shelterbelts for ammonia recapture. The calculator models the potential ammonia recapture based on farm location, soil type, tree species planted and planting density and estimates that a 20% ammonia emission reduction can be achieved[14].

Planting trees for ammonia mitigation should be used as a complimentary measure for reducing on-farm emissions of ammonia to the atmosphere. It takes time for the young trees to mature to the point where the canopy closes and the maximum ammonia capture is reached. There are more tried and tested methods for reducing ammonia emissions on the farm which include housing technologies (e.g. ventilated manure belts), storage covers, and spreading manures & slurries by injection or trailing shoe method. These types of measures should be applied in the first instance when considering managing nitrogen losses from farm practises. Farming Connect in Wales has recently released an online tool to help producers improve air quality by reducing ammonia emissions (*https://businesswales.gov.wales/farmingconnect/improving-air-quality*).

4.4 LITTER AND MANURE MANAGEMENT

The storage and application of litter and manure has important impacts on emissions of nitrous oxide and ammonia. The purpose of a manure cover is to provide a physical barrier reducing the release of ammonia from the manure heap to the air and preventing the run-off of rainwater. Ammonia emissions can be reduced by up to 50% when manure stores are covered[13].

At Farm 1, litter and manure is stored for only short periods on farm (2 – 4 days) before it is exported off-farm twice a week for use by a third party. The litter is stored in a uncovered trailer before it is collected and transported away. The spreading of the litter and manure occurs on a separate farm where all manure is tested prior to application to ensure crop uptake is maximised and risks of losses are minimised. Risks of leaching and runoff into watercourses must be minimised during the spreading of manures onto land6. Spreading should only occur when weather conditions are suitable and by using low emission spreading equipment and field margins and buffers should always be maintained. A large separation distance between field heaps of manure and surface and/or underground watercourses such as drains, boreholes, wells, surface waters and springs also reduces the risk of any leachate impacting watercourses.

At Farm 2, litter and manure is removed on completion of the flock and is stored in uncovered field heaps throughout the flock cycle. The litter and manure is spread onto neighbouring fields using a rear discharge spreader. Excessive application of hen manure to cropland can lead to nutrient runoff to waterbodies however this is mitigated on the farm by maintaining wide field margins and buffer strips along water courses and ensuring manure is only spread onto land when conditions are suitable.

In some parts of the country, there are now large numbers of farms with free range layer units. Locally, this can mean a surplus of poultry manure relative to demand from nearby farms. Additional manure haulage costs may result if litter and manure is transported further afield. Farm 1 has experienced a 80% drop in value of poultry manure as there is an oversupply in the area with no increase in demand.

4.5 FEED SOURCING (LAND USE)

Both farms acknowledge that there is a gap in knowledge regarding ration ingredients and quantities of soya used in layer feed. This highlighted the need to further engage with feed suppliers to provide this information. Both farms emphasised that cost implications would be important to consider if a switch to alternative feeds were to be proposed. Industry estimates suggest that as little as 1 - 2% of soya imported into the UK is from sustainable certified sources under the Roundtable on Responsible Soya (RTRS) programme due to the premium price it demands[15].

Poultry rations are heavily dependent on imported ingredients, but fluctuations in global markets leave producers open to financial uncertainty and potentially high costs. Developing the supply of home-grown or local ingredients is becoming increasingly important. Layer units that are part of a mixed farming enterprise may have the option to grow and mill homegrown feed such as[16]:

- Dehulling protein crops such as peas and beans. The concentration of two important amino acids can be increased by dehulling. Lysine content, for example, can be increased by 13% in peas and 31% in beans, and methionine by 20% in peas and 37% in beans.

- Sunflowers are extremely high in energy and in combination with a high protein ingredient such as dehulled beans, are already making an important contribution to layer rations. Producers will need to have a fall back plan such as taking it as a whole crop silage for ruminant feed if crop growth is affected by adverse seasonal conditions. There are also post-harvest and processing issues to be considered as sunflower cannot be used raw. The high moisture content makes crimping essential, and the high oil levels mean the grain will not keep for more than a few months.

- Naked oats have strong potential as a poultry feed, because of their high oil content and proportionately higher levels of methionine and lysine, which are limited in many organic diets.

4.6 POTENTIAL ENVIRONMENTAL SUSTAINABILITY INDICATORS

To measure environmental sustainability, indicators can be used to demonstrate how sustainable different practices are on farm. Table 4 presents a list of indicators that could be used to measure environmental sustainability within free range egg production in the UK. Table 5 then illustrates values obtained from each pilot farm as part of this study. The next stage is to determine wider guidance on sustainability limits and ranges to determine what is considered poor, average and best performance.

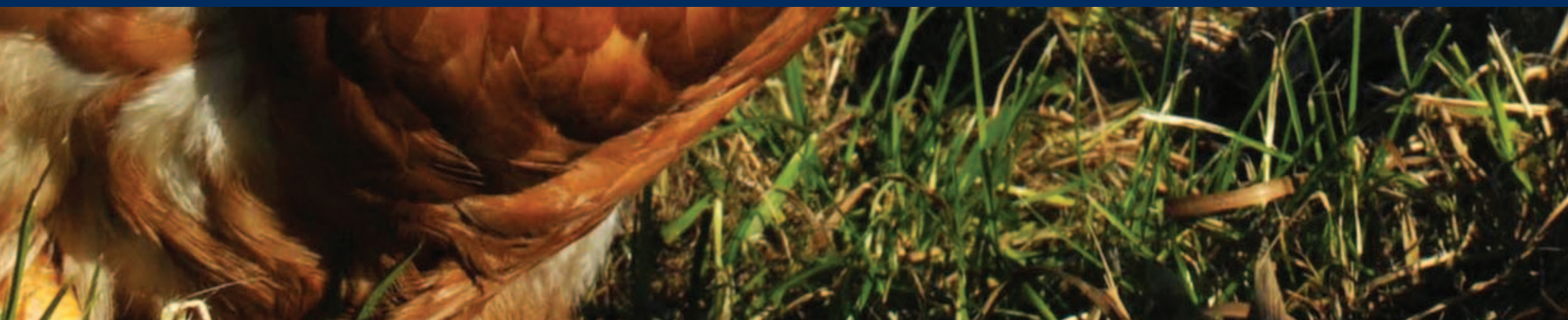
Table 4 – Indicators of environmental sustainability

Sustainability dimension	Theme	Indicator
Environmental	Emissions	Emissions of carbon dioxide equivalent per kg of eggs (kg CO_2e / kg eggs)
	Biodiversity	Percentage (%) of tree cover on range Area (ha) of wildflowers or habitat planted for pollinators
	Energy use	Energy usage (kwh) per kilogramme of eggs produced Proportion of energy obtained from renewable sources (%)
	Water use	Water use (L) per kilogramme of eggs produced or per hen
	Air quality	Emissions of ammonia (NH_3) per kilogramme of eggs produced or per hen Percentage (%) of sheds with planted hedges to buffer and screen ammonia emissions
	Litter & manure	Percentage (%) of litter stores covered Percentage (%) of litter stored more than 50m away from watercourses Percentage (%) of litter stored on hard standing surfaces (e.g. concrete)
	Land use	Percentage (%) of soya meal sourced from sustainable certified sources through the Roundtable on Responsible Soya (RTRS)

Table 5 - Example indicators of environmental sustainability from each farm

Theme	Indicator	Farm 1	Farm 2
Emissions	Emissions of carbon dioxide equivalent per kg of eggs (kg CO2e / kg eggs)	3.01	3.44
Biodiversity	Percentage (%) of tree cover on range	100%	31%
	Area (ha) of wildflowers or habitat planted for pollinators	0	0
Energy	Energy usage (kwh) per kilogramme of eggs produced	0.14	0.22
	Proportion of energy obtained from renewable sources (%)	16%	36%
Water	Water use (L) per kilogramme of eggs produced	2.1	3.9
Ammonia	Percentage (%) of sheds with planted hedges to buffer and screen ammonia emissions	100%	100%
Litter & manure	Percentage (%) of litter and manure stores covered	0%	0%
	Percentage (%) of litter and manure stored more than 50m away from watercourses	100%	100%
	Percentage (%) of litter and manure stored on hard standing areas	100%	0%

5 SUMMARY AND RECOMMENDATIONS



5.1 TRANSITIONING TO NET ZERO

The literature review and greenhouse gas emission calculator used in this project demonstrated that the carbon footprint for the two free range layer units was 3.01 and 3.44 CO2e/kg eggs. Results in literature vary greatly depending on the boundary and scope of the calculation.

In a 2014 article in Poultry Science, greenhouse gas emissions averaged 1.6 kg of CO2e/kg eggs. Of these emissions, 63% represent embodied carbon in poultry feed where production is heavily dependent on cereals and soya, with associated high emissions from industrial nitrogen production, land-use change, and transport3,17. An Australian life cycle assessment of free range egg production also showed similar average emissions of 1.6 kg CO2e/kg eggs[17] for farm gate impacts. The Centre for Innovation and Excellence in Livestock (CIEL) published a study in 2020 showing the carbon footprint of free range egg production to be 3.38 kg of CO2e/kg eggs using a full life cycle analysis[18] and another study presented a very similar footprint of 3.38 kg of CO2e/kg eggs3.

Key emission reduction strategies for producers include:

- Investing in renewable energy for farm use
- Covering manure stores before export off farm
- Reducing layer mortality rate
- Increase laying rates
- Research alternative proteins for feeds over the long term

Opportunities to increase carbon sequestration to offset residual emissions should then be investigated and may include:

- New areas of tree planting
- Increasing length and width of hedgerows
- Improving soil organic matter and increasing carbon stored in soils

The calculation of greenhouse gas emissions in this report is based on two farms only. A broader spectrum of egg producers is required to produce results that could be considered representative of the whole UK free range egg production industry. To further improve the accuracy of emissions calculations, investigation of feed rations and source country of origin is required. Emissions associated with feed production are the largest source of emissions from layer units and must be seen as a high priority for the industry when transitioning to net zero. Feed suppliers need to be part of the conversation and planning to improve traceability of raw ingredients with high embedded carbon footprints (such as soya) and encourage uptake and investment into alternative protein sources.

For producers that are wanting to calculate the carbon footprint of their layer unit it is recommended to:

- Choose a flock cycle as a reference period to base data collection on. It's often best to align the reference period to the farm's financial year to enable ease of data collation as many inputs can be obtained from financial costs and accounts such as:
  - Diesel and fuel use
  - Electricity use
  - Water use
- Gather key data inputs such as:
  - Flock size
  - Mortality rate of hens
  - Quantity of eggs produced (sold to packhouse)
  - Average egg weight (g)
  - Tonnes of litter purchased and litter type
  - Quantity of manure exported off farm
  - Land area of range
  - Quantity of ration fed during each stage of the laying cycle
  - Raw ingrediants in feed ration
  - Average daily dry matter intake per hen (g/day)
  - Transport distances between pullet supplier and feed supplier to the farm
  - Split of overheads or resource use between different enterprises on the farm (e.g. for diesel, oil, petrol, electricity) if a mixed farm

5.2 WIDER SUSTAINABILITY PRACTICES

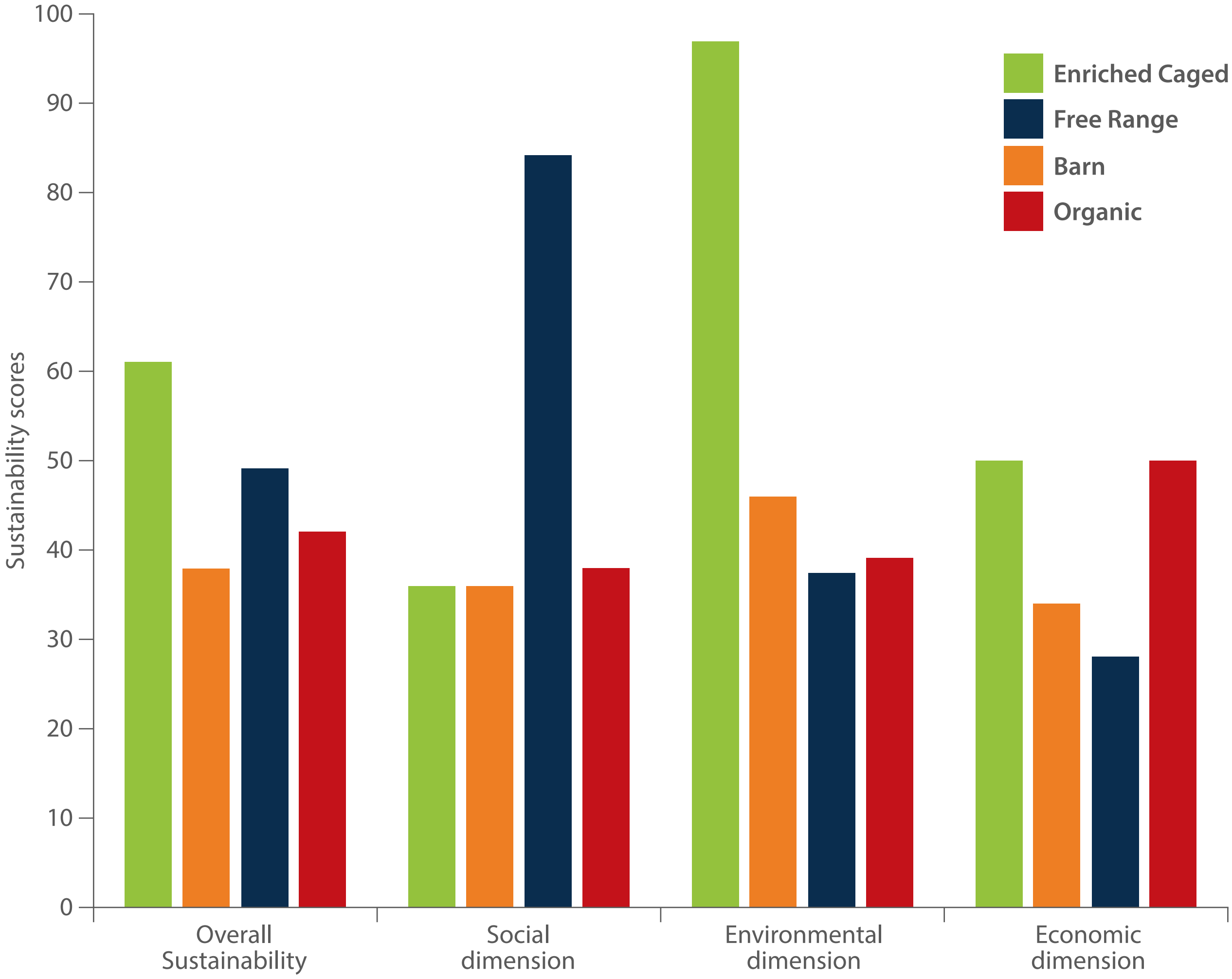
To demonstrate environmental sustainability within the free range egg production industry, defined targets and units of measurement are needed to provide a framework, linking to Sustainable Development Goals where appropriate. This report has identified the following six key themes to consider which could begin to set standards for environmental sustainability within the sector:

1) Greenhouse gas emissions
2) Energy efficiency and renewable energy
3) Water quality
4) Ammonia and air quality
5) Litter and manure management
6) Feed sourcing

Once a sustainability framework is set, collection of benchmarking data across a greater cross section of the free range industry is required. The data will provide a robust basis for targeting industry improvement and could be integrated into future studies or sustainability roadmaps. A wider dataset will also provide guidance on sustainability limits and ranges to determine what is considered poor, average and best performance.

A study in The Netherlands in 2015 selected indicators within the social, environmental, and economic dimensions, after which parameter values and sustainability limits were set in order to quantify sustainability[19]. The four main egg production systems in The Netherlands were then scored and the results are shown in Figure 5 which shows that free range egg production had the highest sustainability scores in the social dimension, and the second highest overall. A similar study in the UK could be undertaken using a tailored set of indicators that match the different regulatory requirements and view of stakeholders.

Figure 5 – Overall sustainability scores and scores in the social, environmental and economic dimension for enriched cage egg production, barn egg production, free-range egg production, and organic egg production[19].



Phase 2 of this project will seek to investigate other measures of sustainability for the social and economic dimensions in the UK context. This may include the following indicators as shown in Table 6.

Table 6 – Potential indicators of social and economic sustainability

Sustainability dimension	Theme	Indicator
Social	**Consumer demand / Food quality**	Nutritional value of eggs (grams of micro/macro nutrients / kg egg
		Egg shelf in days
		Egg size (g)
	Animal welfare	Total square meters (m^2) per hen
		Total square meters (m^2) of range space per hen
		Percentage (%) mortality
		Percentage (%) of feather picking
		Use of infra-red beak trimming to prevent feather picking and aggression in flocks
Economics	**Productivity**	Cost of production
		Price per kg eggs sold
		Revenue / profitability

This will complete a holistic review of sustainability within free range egg production in the UK covering environmental, social and economic dimensions. A fully developed sustainability framework with a core set of indicators and limits will help communicate the benefits of free range egg production and can provide transparent evidence linked to measurable sustainability targets.

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